

AN ATLAS OF POLARIZATION FEATURES OF LIGHT REFLECTED BY DESERT SAND, WHITE SAND AND SOIL

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Project No. 7621
Task No. 762103
Work Unit No. 76210301

Scientific Report No. 3
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Contract Monitor: Robert W. Fenn
Optical Physics Laboratory

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CORRIGENDA

Page 77 The constant term in the series should be 7.63 instead of 6.69

Page 134 Read $-0.38 \cos \phi$ instead of $-0.12 \cos \phi$

Page 203
$$P(\phi) = 7.69 + 2.57 \cos \phi - 0.38 \cos 2\phi + 0.05 \cos 3\phi$$
$$- 0.02 \cos 4\phi + 0.00 \cos 5\phi - 0.08 \cos 6\phi$$
$$+ 0.06 \sin \phi + 0.12 \sin 2\phi + 0.03 \sin 3\phi$$
$$- 0.06 \sin 4\phi - 0.00 \sin 5\phi$$

ABSTRACT

The results of an extensive series of measurements of the degree of linear polarization of light bidirectionally reflected by samples of desert sand, white sand and soil under various conditions of illumination are presented in graphical form. Measurements have been made in three spectral intervals (bandwidth $\sim 150 \text{ \AA}$) centered on $\lambda\lambda 3970, 4865, 5890\text{\AA}$ and 'white light' with a simple 'rotating-analyzer' type reflectometer. Simple Fourier series representations have been established for the azimuthal dependence of the degree of linear polarization of the reflected light for 'white light' measurements. The results of the corresponding error analysis are shown in an error curve.

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ACKNOWLEDGMENTS

The authors are thankful to Professor Zdenek Sekera, Project Director, for his interest in the work reported here. The competent computational and technical assistance extended to the authors by Miss Barbara Skolsky and Messrs. Chesebrough, Dibble, Farnow, Fauquet and Palomino is herewith gratefully acknowledged. Mrs. Sherry Lovell is responsible for the neat execution of the manuscript.

INTRODUCTION

The study of the reflection properties of natural formations constitutes an important part of the extensive experimental research program which is being pursued in the Atmospheric Optics and Radiation Laboratory of the Department of Meteorology, University of California, Los Angeles. The results of preliminary studies have been reported upon by Chen et al¹ and Chen and Rao². These studies revealed that a detailed examination of the azimuthal dependence of the polarization of light diffusely reflected by natural formations would be an important prerequisite even for a semi-empirical understanding of scattering of light by optically rough surfaces. The need for and relevance of such studies have also been keenly felt in investigations directed towards the interpretation of radiation measurements from meteorological satellites.

EXPERIMENTAL STUDIES

The experimental geometry is shown in Figure 1a. The reflecting surface of the sample defines the equatorial plane. θ_0 is the angle of illumination; θ is the nadir angle of observation. The principal plane of the source S is defined by the direction of illumination and the normal to the equatorial plane. It is the reference plane for the determination of

the azimuth ϕ of the plane of observation defined by the direction of observation and the normal to the equatorial plane.

In the present measurements, the angle of illumination θ_0 has been set equal to $0^\circ 00'$, $53^\circ 00'$ and $78^\circ 30'$ successively. The azimuth angle has been varied in steps of $30^\circ 00'$ over the entire circle. In any plane of observation defined by a particular value of ϕ , the reflected radiation has been examined over the region $0^\circ 00' \leq \theta \leq 80^\circ 00'$ by varying θ in steps of $10^\circ 00'$. An additional set of measurements has been obtained corresponding to $\theta = 75^\circ 00'$.

Details of the 'rotating-analyzer' type reflectometer and the data acquisition system are shown in Figures 1b,c and d. Detailed descriptions have been given elsewhere by Chen et al (Op. Cit.). Samples of white sand (gypsum derived translucent grains of dimensions of the order of 0.5 mm), desert sand (silica derived translucent grains of dimensions of the order of 0.5 mm) and soil (opaque particulates of dimensions of the order of 1 mm) have been studied when illuminated either with natural (unpolarized) light or with plane polarized light with the plane of polarization either parallel or perpendicular to the principal plane of the source. The choice of these samples in the first instance was governed by the fact that they have been frequently examined both in the laboratory and on the field by investigators elsewhere^{3,4}.

The degree of linear polarization of the reflected light has been measured in three narrow (bandwidth $\sim 150 \text{ \AA}$) spectral intervals centered on $\lambda\lambda 3970, 4865$ and 5890\AA . In addition, 'white light' measurements have also been made with the interference filter removed from the optical train in the reflectometer.

REPRESENTATION OF THE DATA

The analog data on strip-charts has been employed to compute the degree of polarization, P , with the use of the formula $P(\%) = 100 \frac{V_{\text{MAX}} - V_{\text{MIN}}}{V_{\text{MAX}} + V_{\text{MIN}}}$ where V_{MIN} and V_{MAX} are respectively the minimum and maximum values of the photovoltage over half a revolution of the analyzing Glan-Thompson prism. Corresponding to a given state of polarization of the illumination, angle of illumination and nadir angle of observation, measurements have been made over the azimuth circle by varying ϕ in steps of $30^\circ 00'$. The instrument configuration was such that, in certain planes of observation, corresponding to particular values of θ and θ_0 , meaningful results could not be obtained as the shadow of the instrument was cast on the surface of the sample. The probable values of the polarization have been determined by graphical interpolation in those cases.

The measured azimuthal dependence of the polarization of the reflected light is shown in Figures 2 to 262. In those cases when the

illumination is plane polarized, the orientation of the plane of polarization is indicated by a properly oriented arrow; thus a vertical arrow indicates that the illumination was polarized parallel to the principal plane of the source and a horizontal arrow indicates that the illumination was polarized normal to the principal plane of the source.

It is apparent from the data shown in Figures 2 through 262 that the degree of polarization of the reflected light exhibits noticeable azimuthal dependence except when the samples are illuminated with natural (unpolarized) light along the nadir direction or when $\theta = 0^{\circ}00'$. This anisotropy is uniformly noticed in all spectral intervals. It is for this reason and for the sake of brevity that only the Fourier series representations of the azimuthal dependence of the polarization of reflected 'white light' are given in the diagrams. The conventional harmonic analysis and synthesis schedules developed by Pollak⁵ have been used in determining the Fourier coefficients. The results of the checks made at three arbitrarily chosen values of ϕ in the case of each of the Fourier series are shown in the relative error curve of Figure 263.

CONCLUSION

The original objective was to attempt a simple empirical representation for the degree of polarization of the reflected light taking into account the θ , θ_0 and ϕ dependencies simultaneously. It has not been possible to attain this objective since the Fourier coefficients vary rather irregularly with θ and θ_0 for given conditions of illumination. The information presented herein can however be used to estimate the degree of polarization of the reflected light at any desired value of the azimuth under given conditions of illumination and observation. Such computations are considered useful in aerial photographic reconnaissance studies and in the interpretation of radiation measurements performed from meteorological satellites.

REFERENCES

1. Hsi-shu Chen, C. R. Nagaraja Rao, and Z. Sekera, Scientific Report No. 2 (AFCRL067-0089), Air Force Contract No. AF19(628)-3850, Department of Meteorology, University of California, Los Angeles (1967).
2. Hsi-shu Chen and C. R. Nagaraja Rao, Brit. J. Appl. Phys. (J. Phys. D.), 1, 1191 (1968).
3. K. L. Coulson, Appl. Opt., 5, 905 (1966).
4. Vincent V. Salomonson, Atmospheric Research Paper No. 128, Department of Atmospheric Science, Colorado State University, Fort Collins (Colo.) (1968).
5. L. Pollak, All Term Guide for Harmonic Analysis and Synthesis (Dublin Stationery Office, 1949).

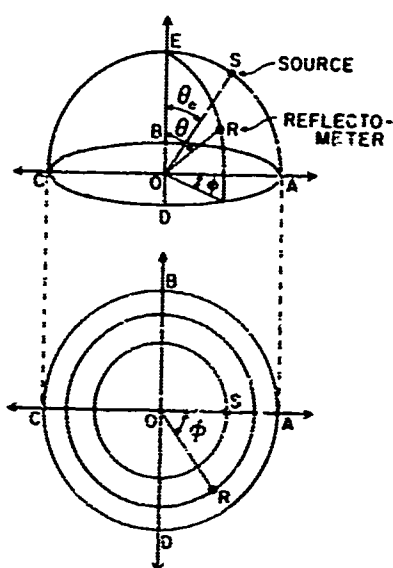


FIG. 1a. EXPERIMENTAL GEOMETRY

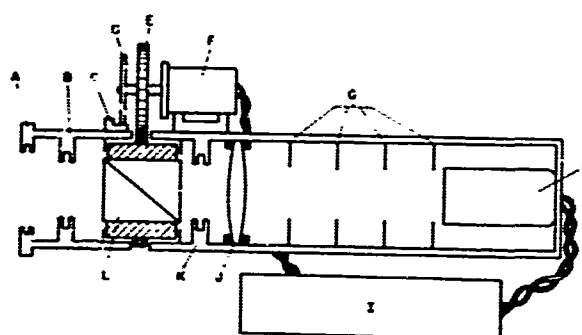


FIG. 1b. THE REFLECTOMETER

A. HOLDER FOR NEUTRAL DENSITY WEDGE B. HOLDER FOR QUARTER WAVE PLATE C. MICROSPINCH D. PROGRAMMED CARTRIDGE ANALYZER DRIVING MECHANISM E. D.C. MOTOR G. LIGHT-EMITTING DIODES H. ASCEP 561-A PHOTOMULTIPLIER TUBE I. AUXILIARY ELECTRONICS J. FUSED QUARTZ K. OPTICALLY TRANSPARENT POLYMER L. CLARK-THOMPSON PRISM



FIG. 1d. DATA ACQUISITION SYSTEM
A: VTVM B: Oscilloscope C: "Wyle" A/D Converter
D: Strip Chart Recorder E: Variable Gain Amplifier
F: "Digitata" Digital Recorder



FIG. 1c. EXPERIMENTAL ARRANGEMENT
A: Source B: Reflectometer C: Sample
D: Altazimuth Drive

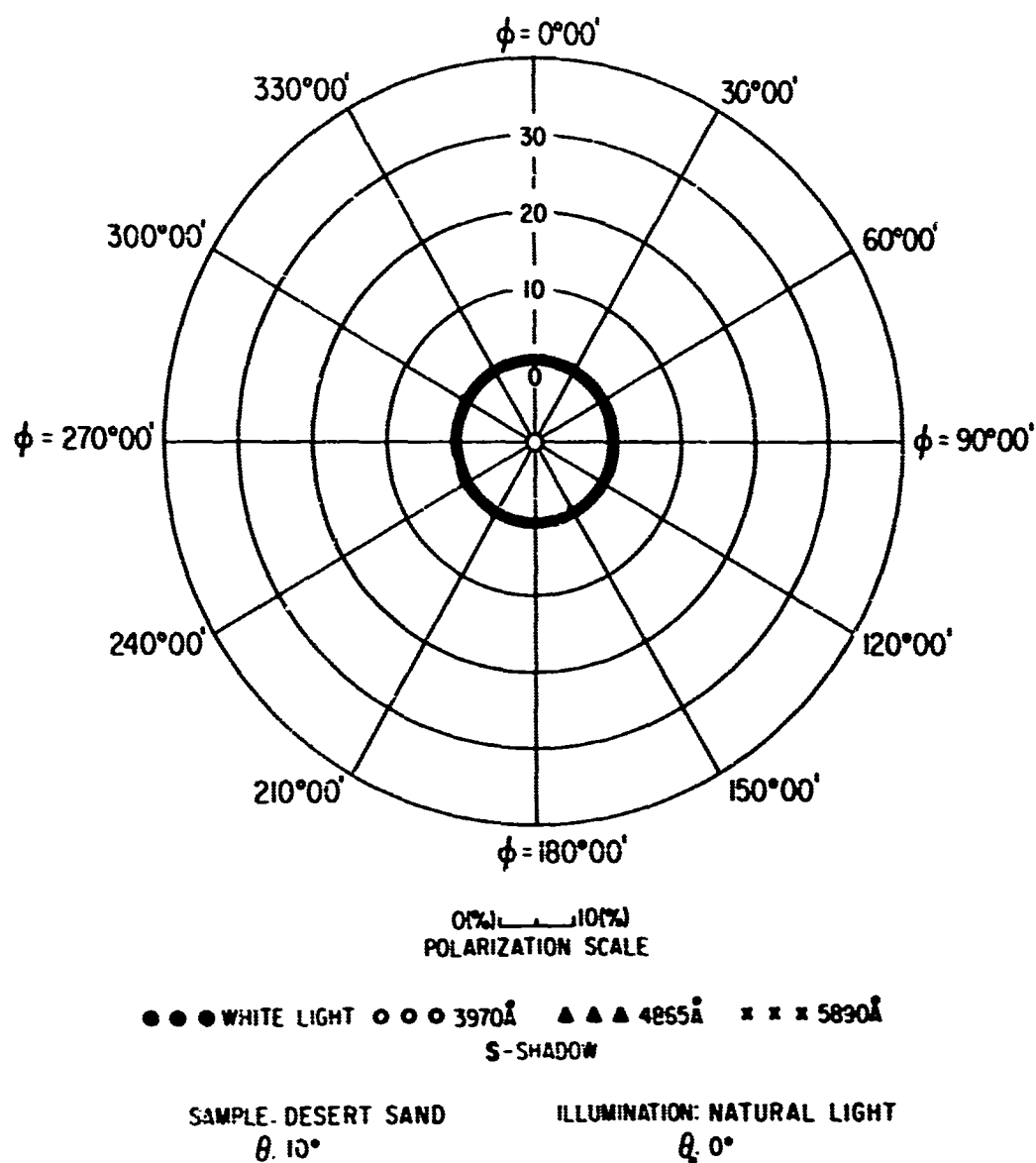
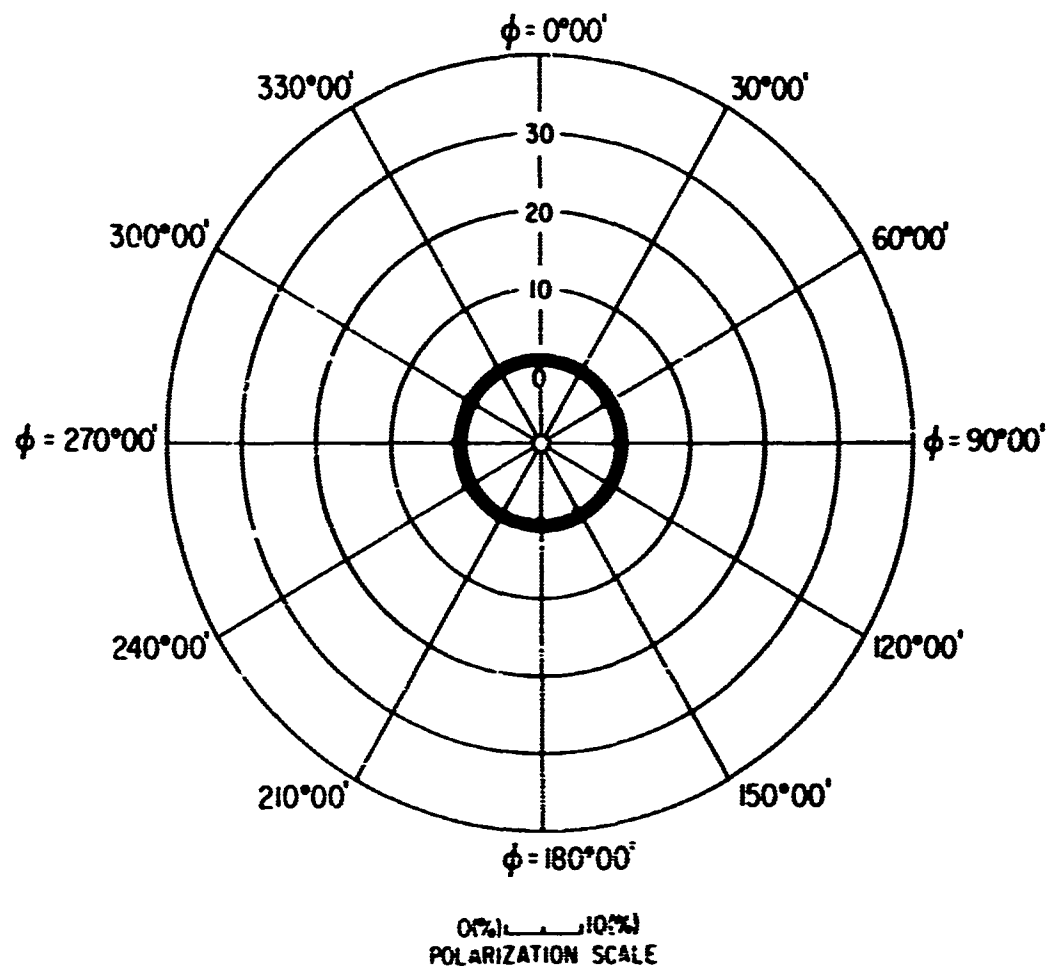


FIG 2. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

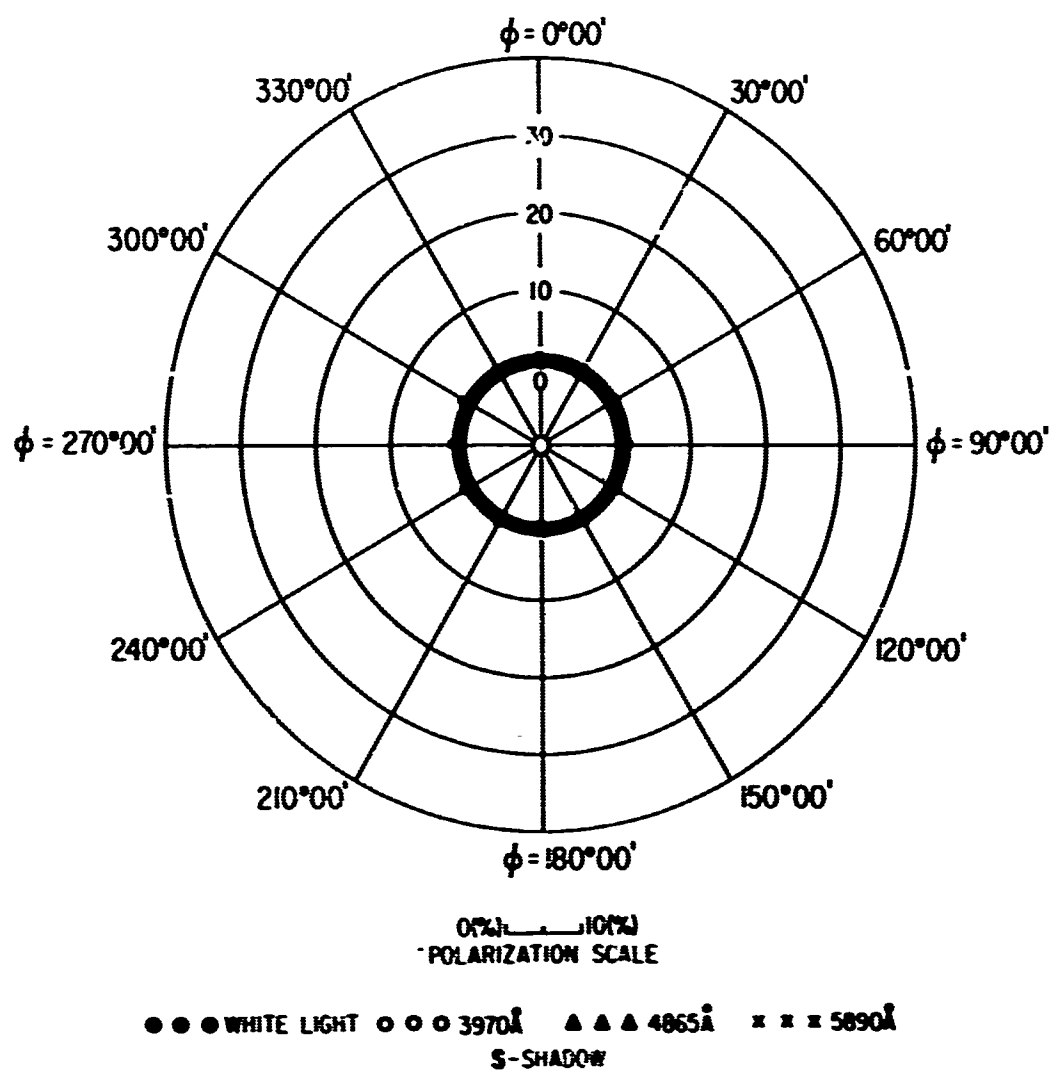


● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
S-SHADOW

SAMPLE: DESERT SAND
 $\theta: 20^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 0^\circ$

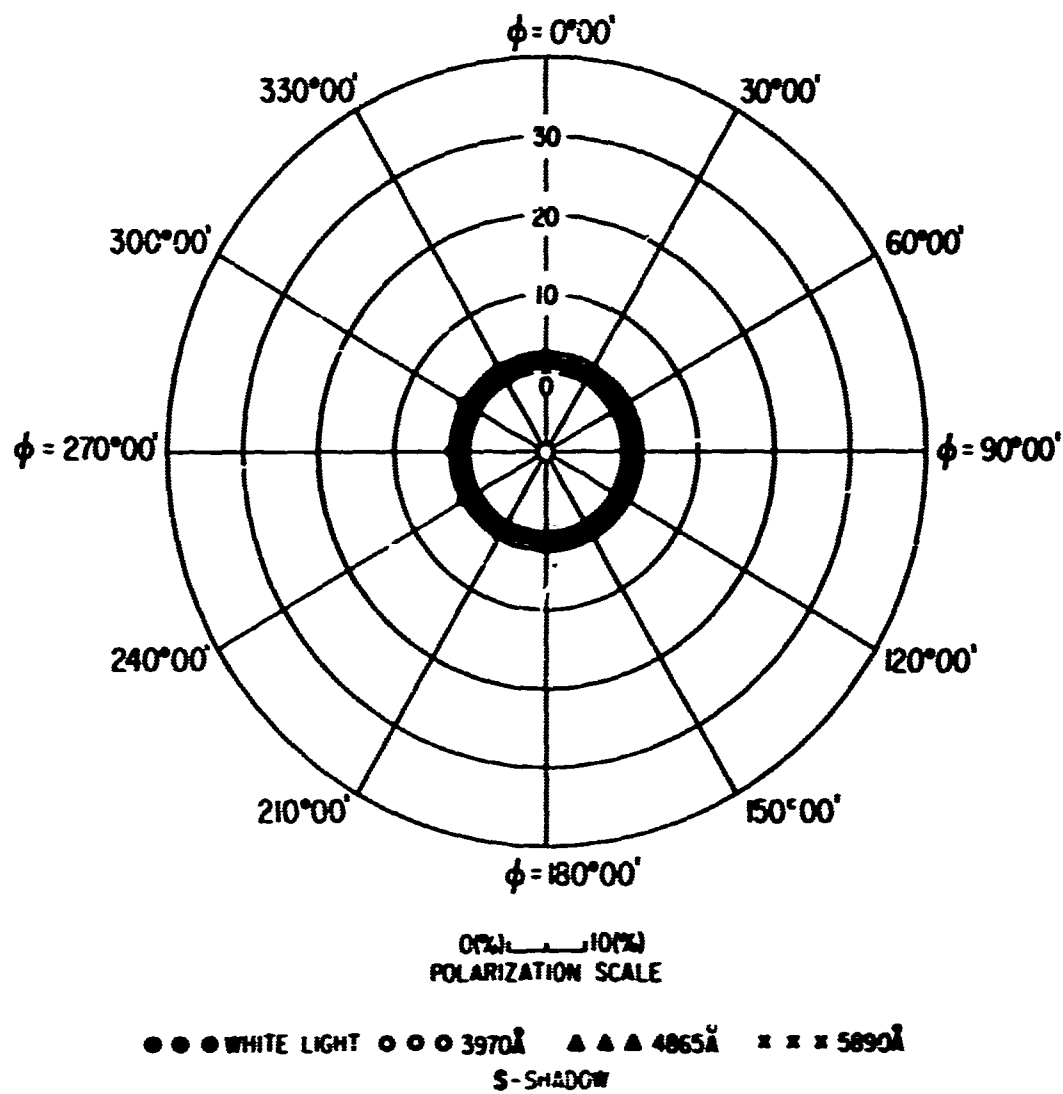
FIG 3. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT



SAMPLE: DESERT SAND
 $\theta: 30^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta: 0^\circ$

FIG. 4. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT



SAMPLE: DESERT SAND
 $\theta: 40^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta: 0^\circ$

FIG 5. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

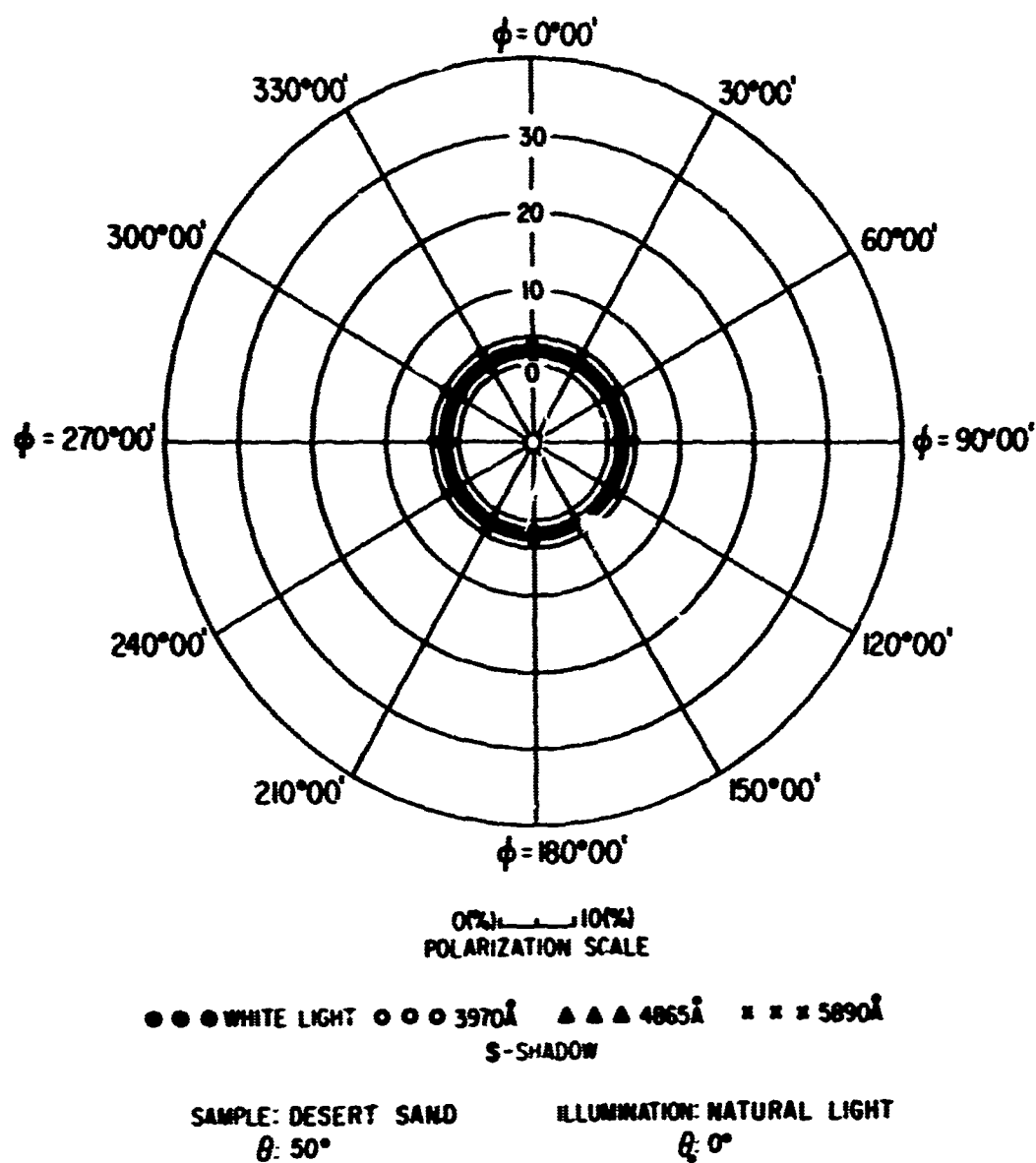


FIG 6. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

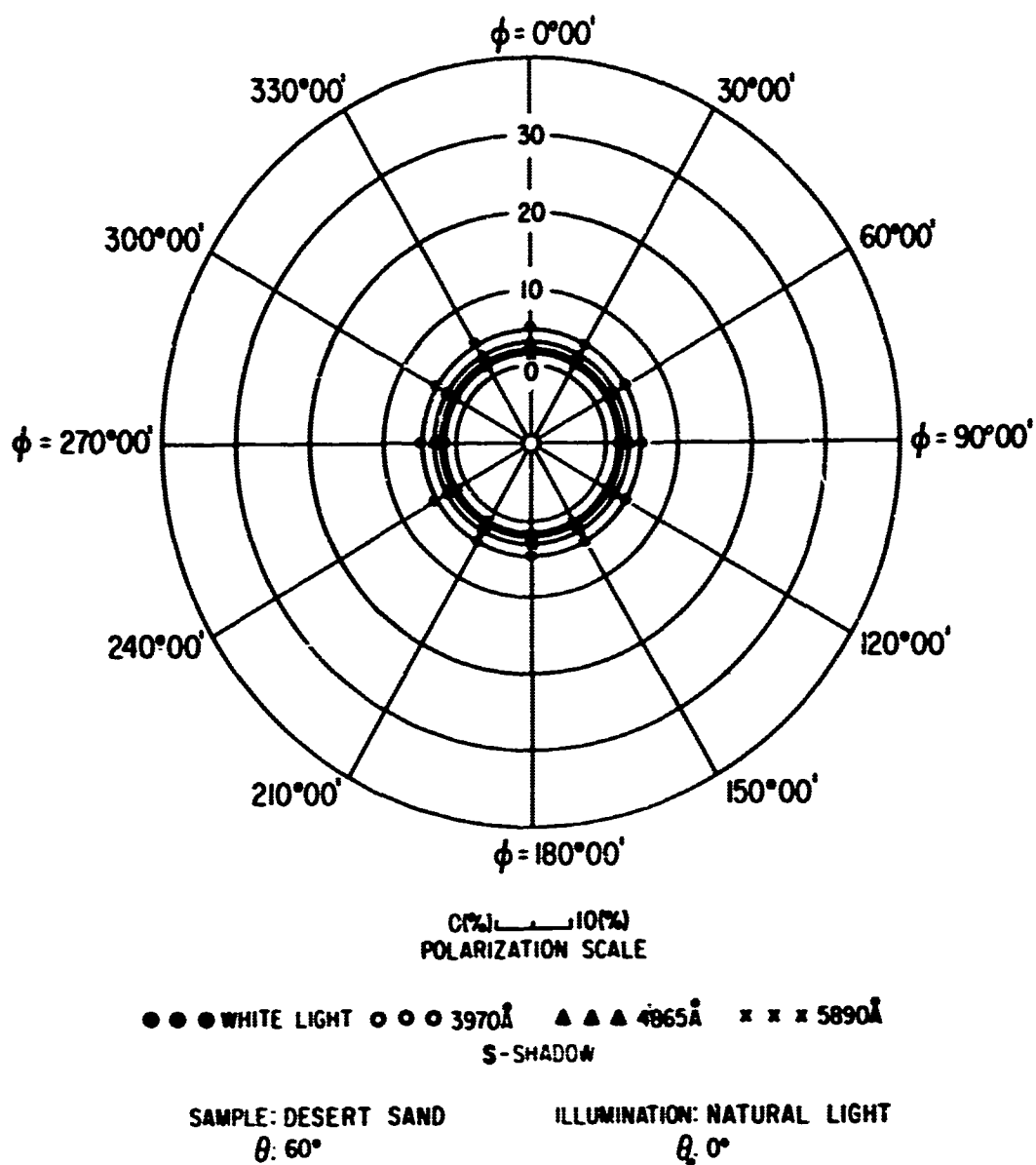


FIG 7. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

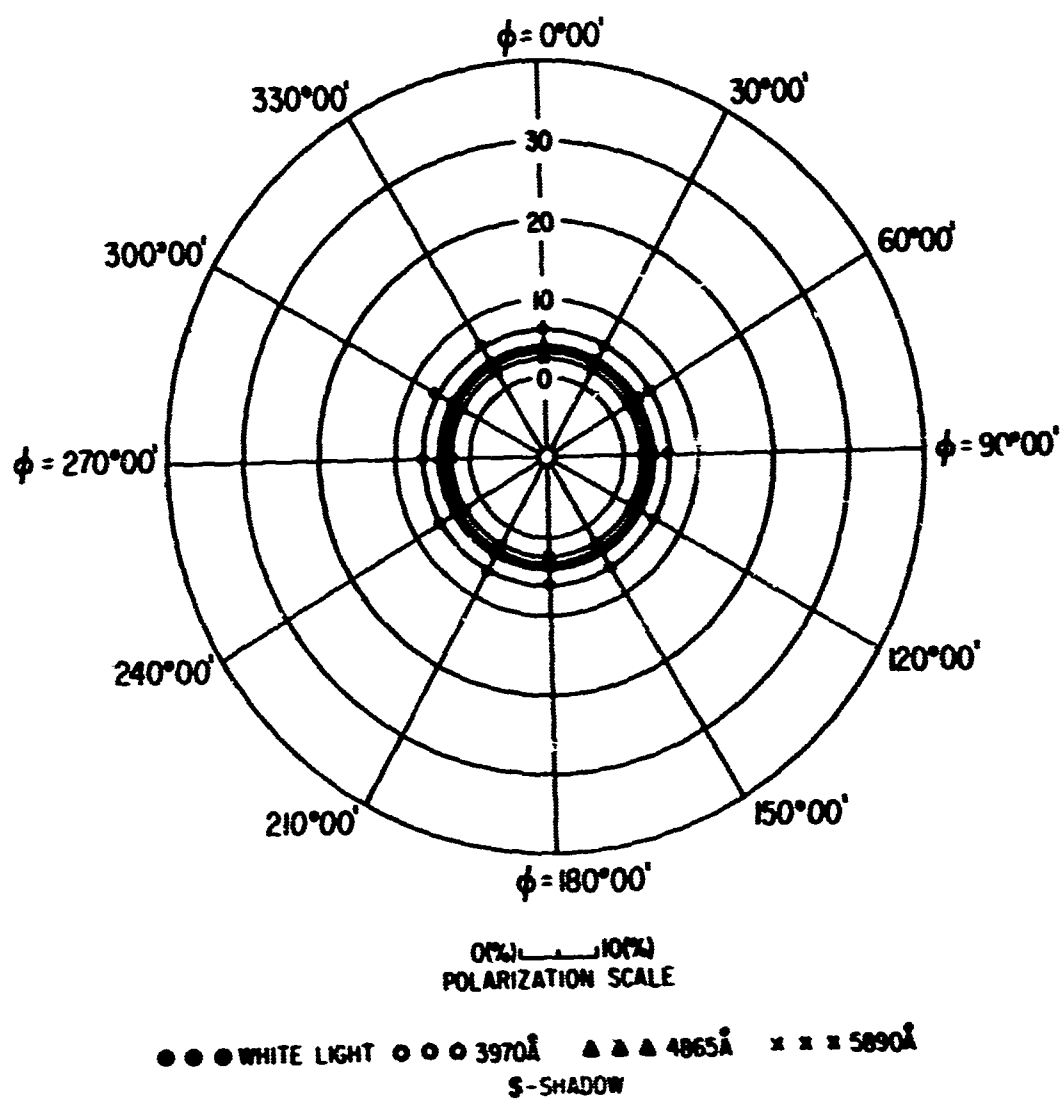


FIG. 8. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

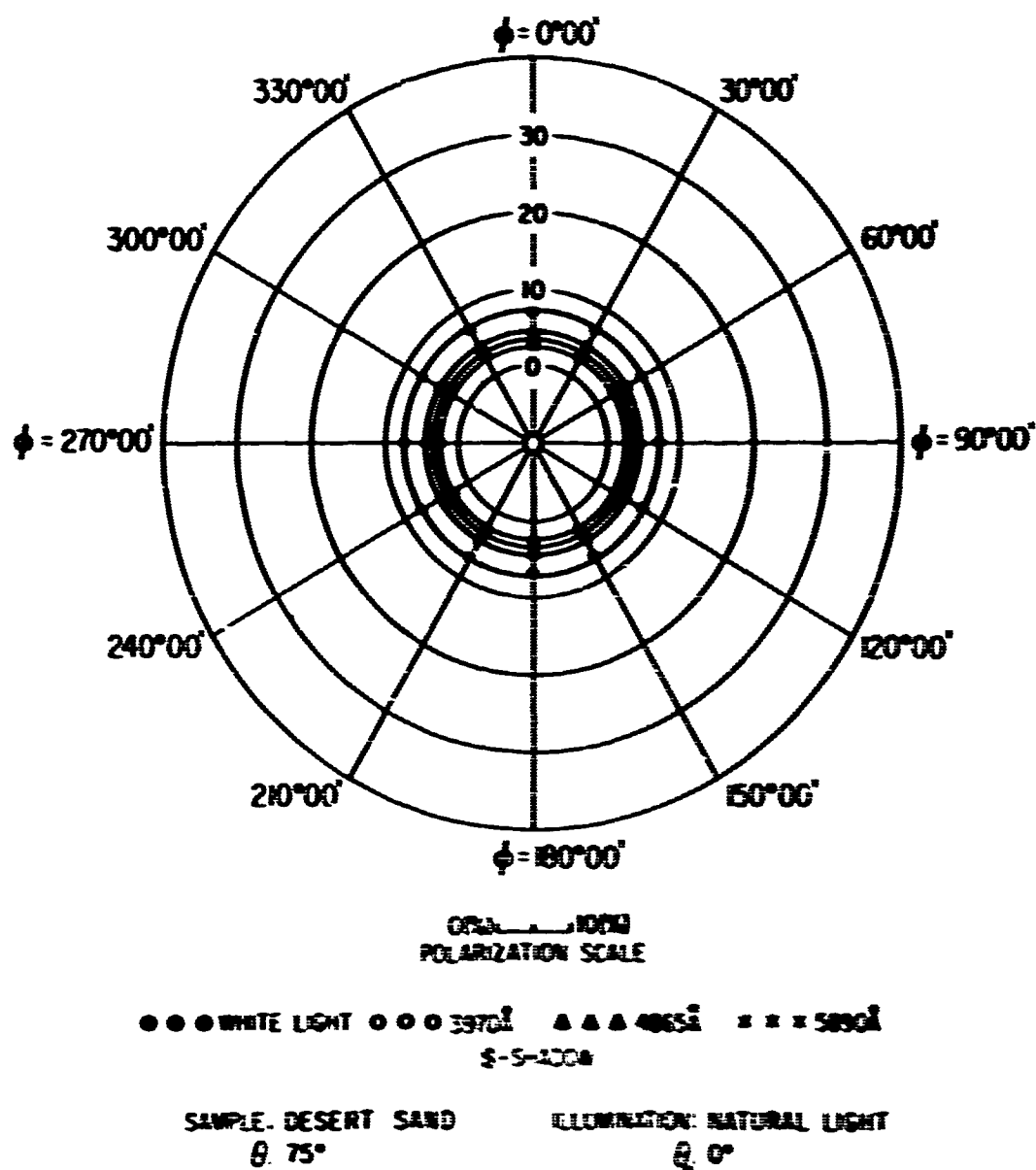


FIG. 9. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

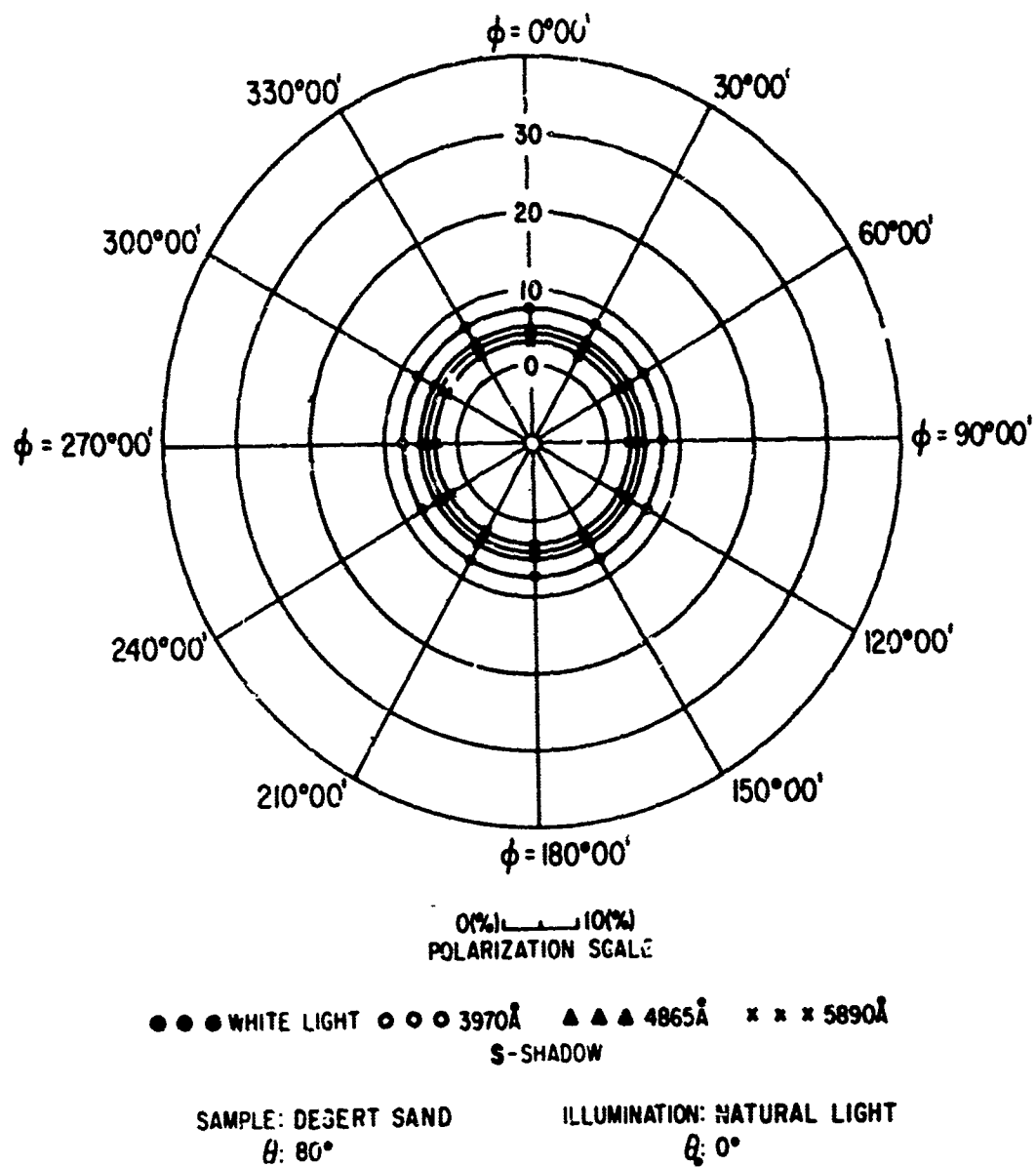


FIG. 10. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

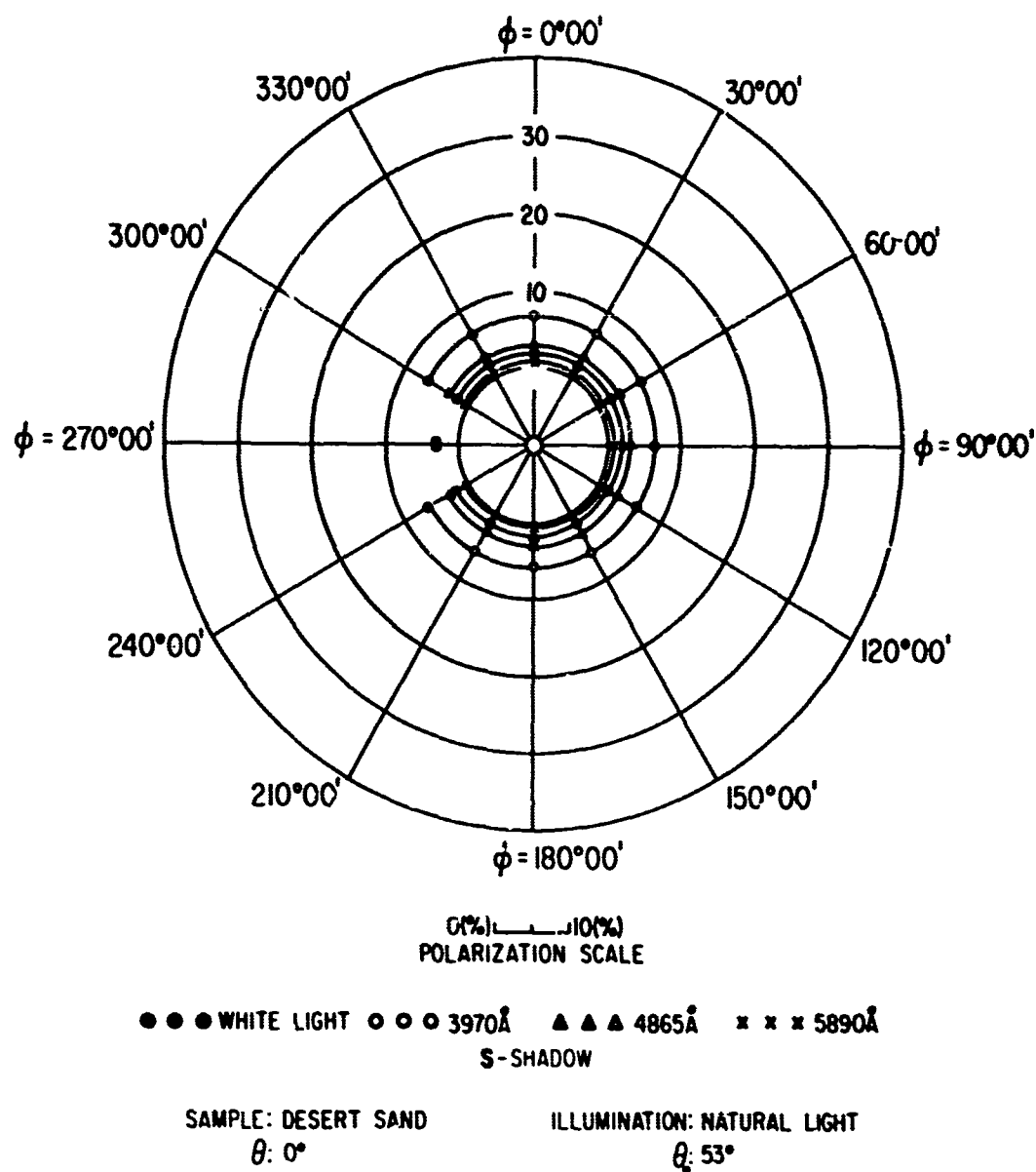


FIG II. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

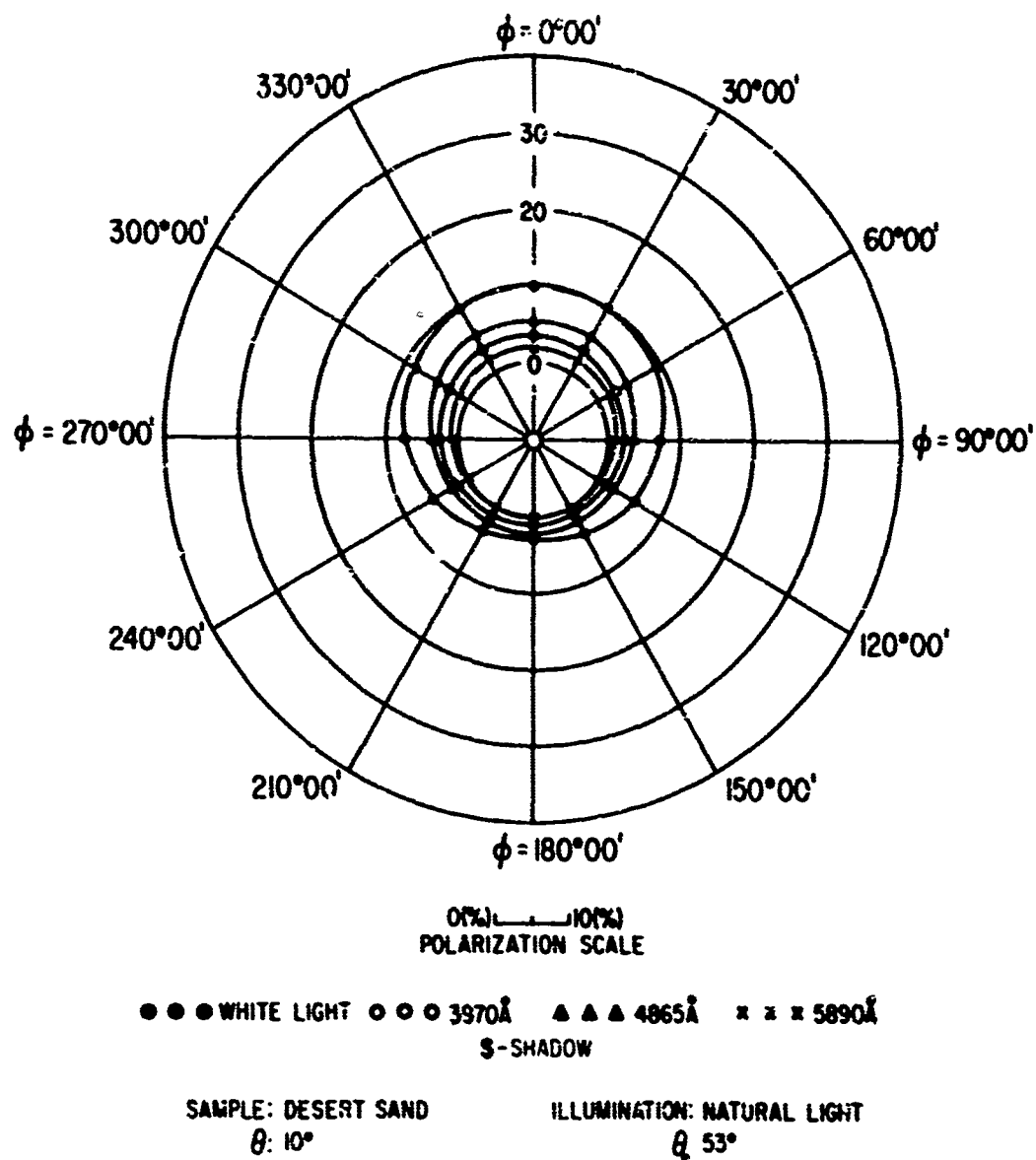


FIG 12. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 2.27 + 1.62 \cos \varphi - 0.06 \cos 2\varphi - 0.12 \cos 3\varphi + 0.26 \cos 4\varphi - 0.25 \cos 5\varphi \\
 & - 0.03 \cos 6\varphi + 0.00 \sin \varphi - 0.07 \sin 2\varphi + 0.08 \sin 3\varphi - 0.19 \sin 4\varphi + 0.18 \sin 5\varphi
 \end{aligned}$$

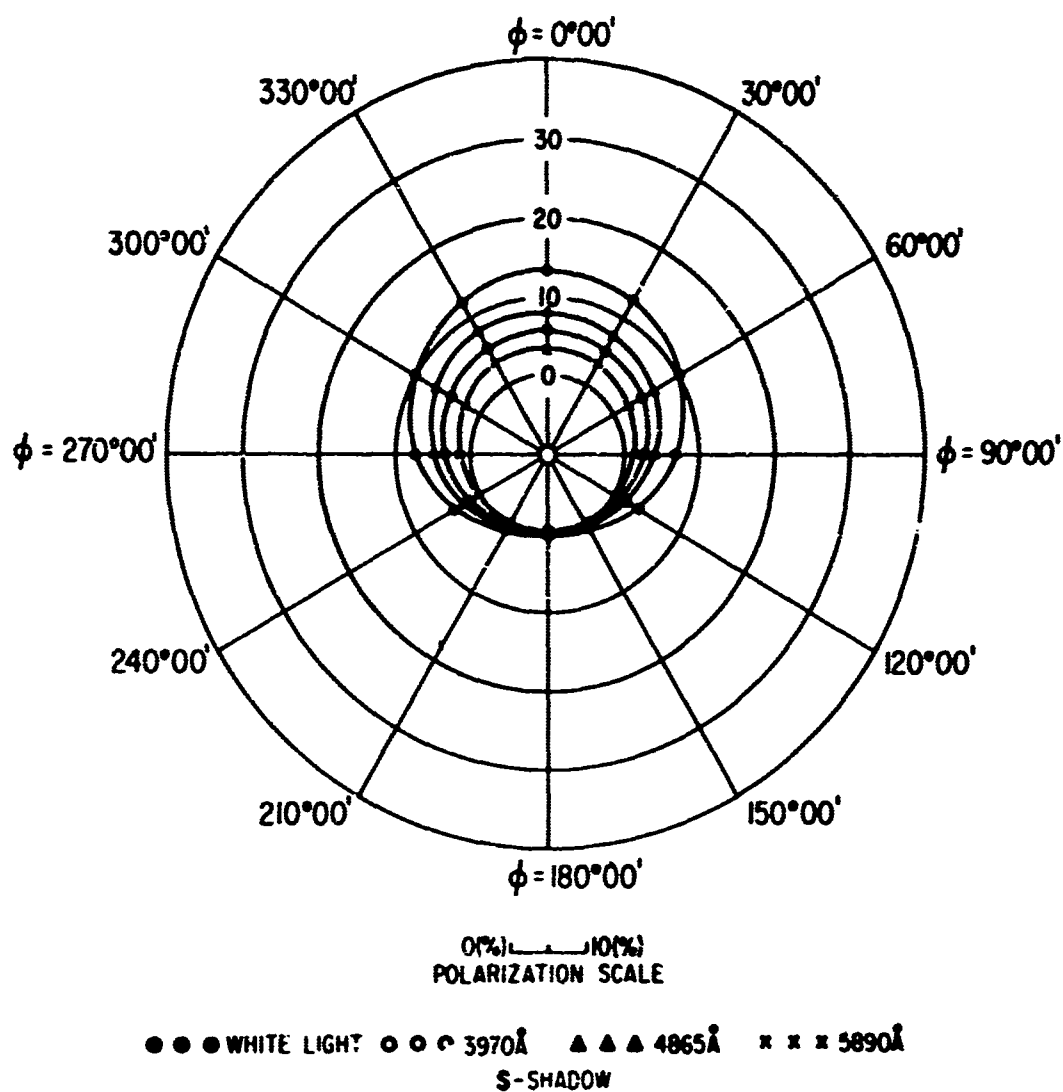
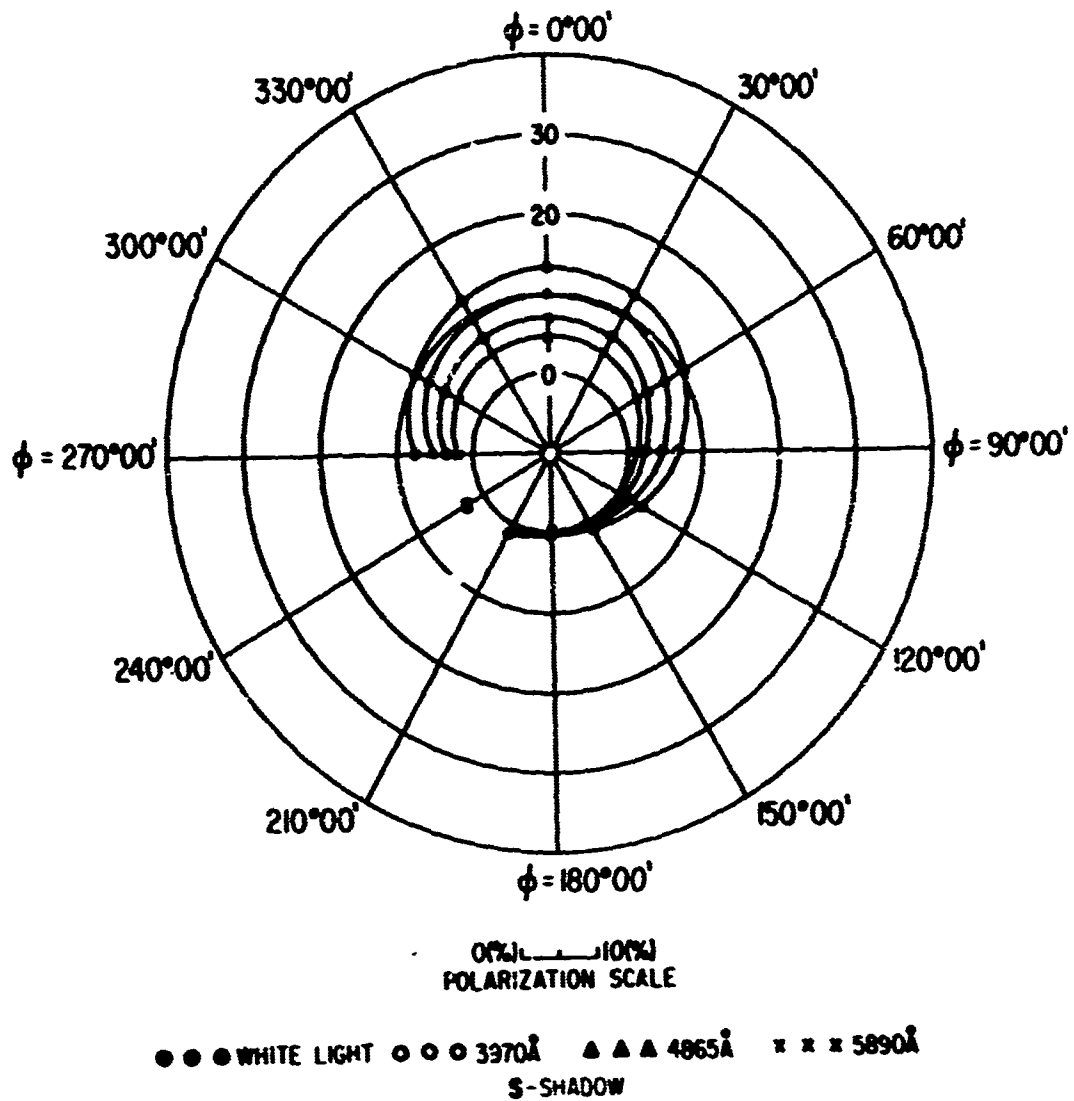


FIG 13. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 2.78 + 2.81 \cos \varphi - 0.02 \cos 2\varphi - 0.33 \cos 3\varphi + 0.09 \cos 4\varphi + 0.12 \cos 5\varphi \\
 & - 0.10 \cos 6\varphi - 0.06 \sin \varphi + 0.01 \sin 2\varphi - 0.03 \sin 3\varphi - 0.16 \sin 4\varphi - 0.23 \sin 5\varphi
 \end{aligned}$$



SAMPLE: DESERT SAND
 $\theta: 30^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta: 53^\circ$

FIG. 14. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 3.28 + 3.46 \cos \varphi + 0.39 \cos 2\varphi - 0.37 \cos 3\varphi + 0.02 \cos 4\varphi + 0.05 \cos 5\varphi \\ - 0.08 \cos 6\varphi - 0.35 \sin \varphi - 0.28 \sin 2\varphi + 0.02 \sin 3\varphi - 0.02 \sin 4\varphi - 0.09 \sin 5\varphi$$

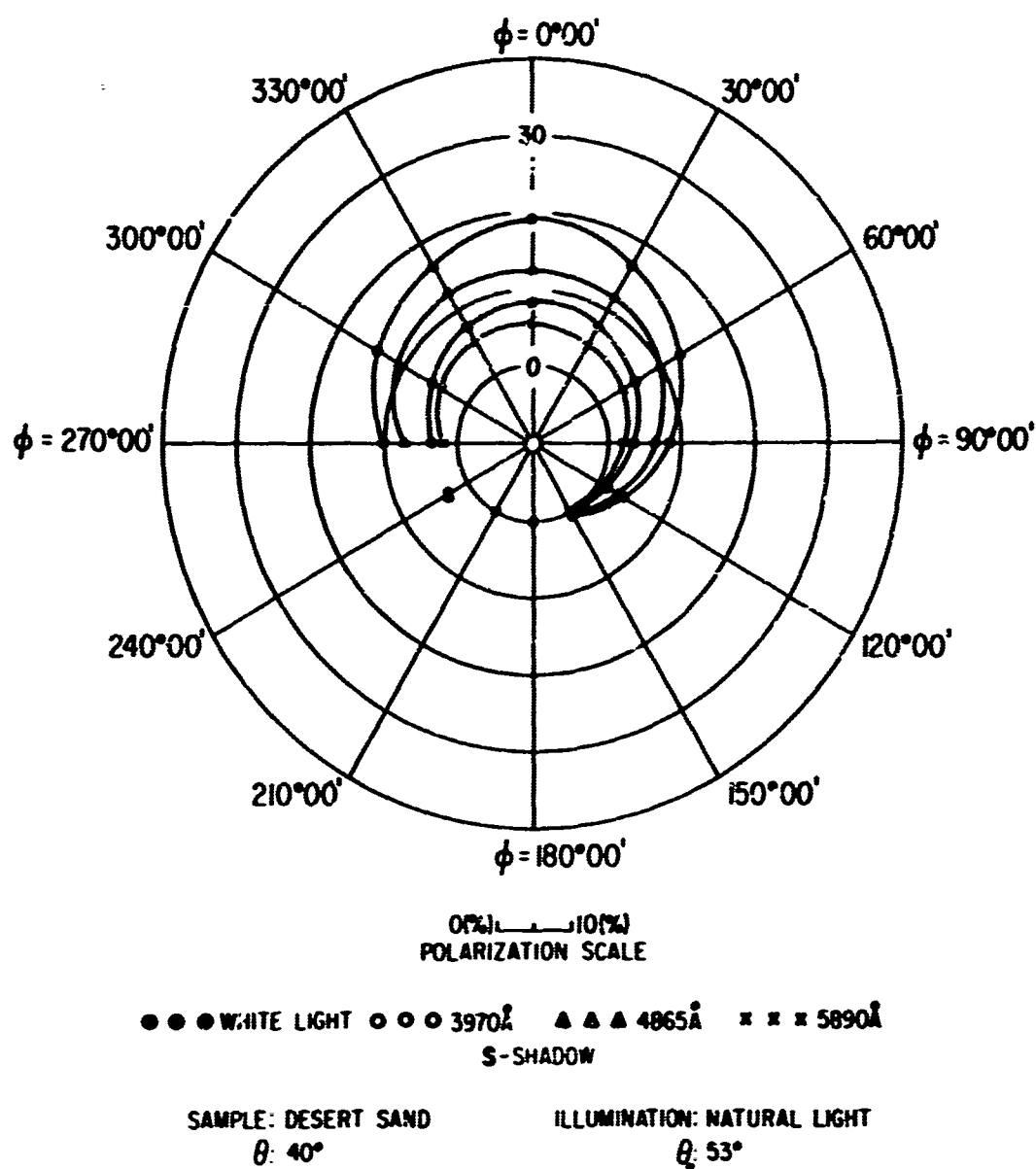


FIG. 15. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 3.82 + 4.22 \cos \varphi + 0.32 \cos 2\varphi - 0.07 \cos 3\varphi + 0.12 \cos 4\varphi + 0.00 \cos 5\varphi \\
 & + 0.15 \cos 6\varphi - 0.24 \sin \varphi - 0.19 \sin 2\varphi - 0.02 \sin 3\varphi + 0.02 \sin 4\varphi - 0.03 \sin 5\varphi
 \end{aligned}$$

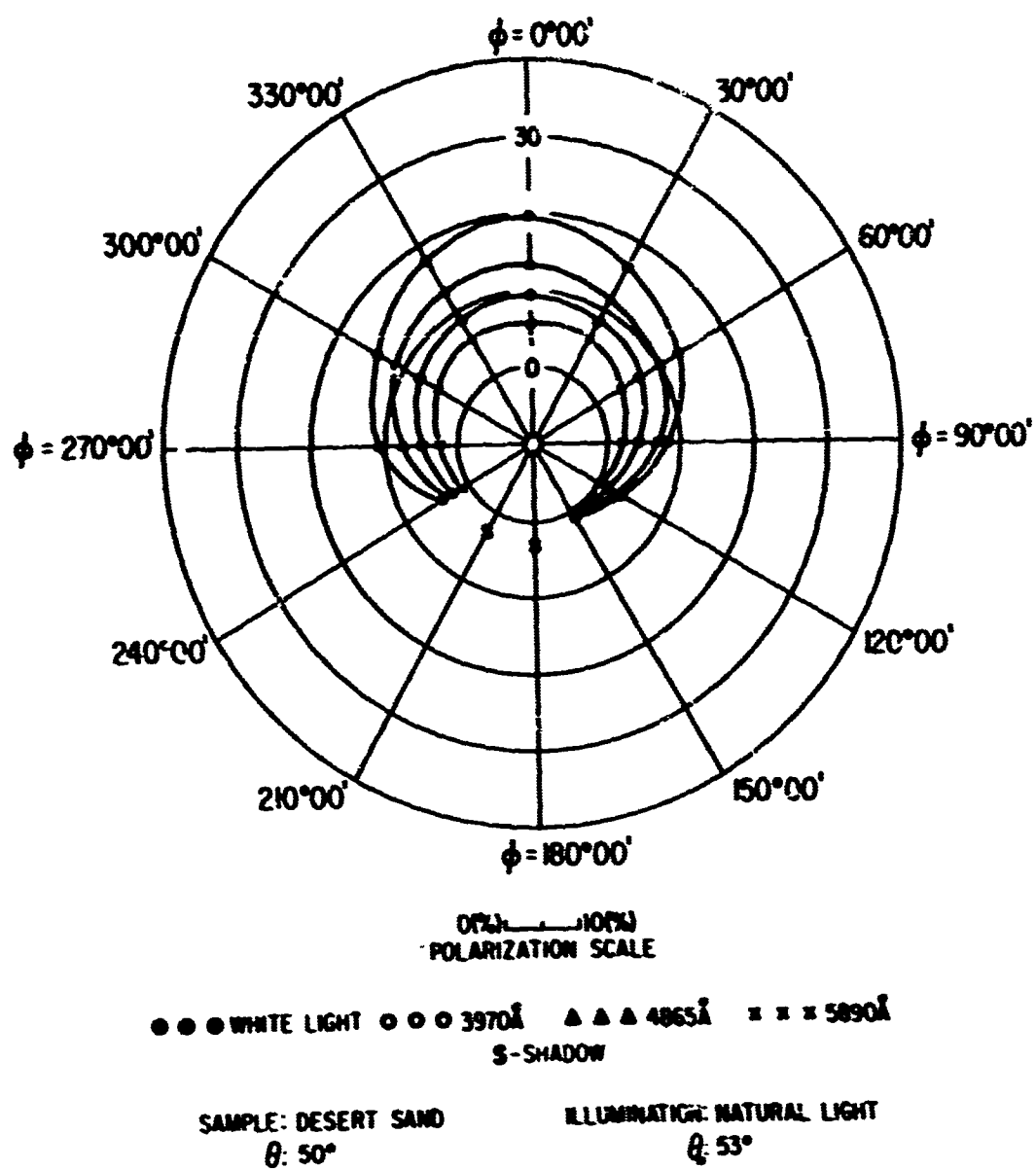


FIG 16. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 4.47 + 4.68 \cos \varphi + 0.13 \cos 2\varphi - 0.05 \cos 3\varphi + 0.23 \cos 4\varphi + 0.10 \cos 5\varphi \\
 & + 0.03 \cos 6\varphi - 0.48 \sin \varphi - 0.06 \sin 2\varphi + 0.02 \sin 3\varphi - 0.12 \sin 4\varphi + 0.15 \sin 5\varphi
 \end{aligned}$$

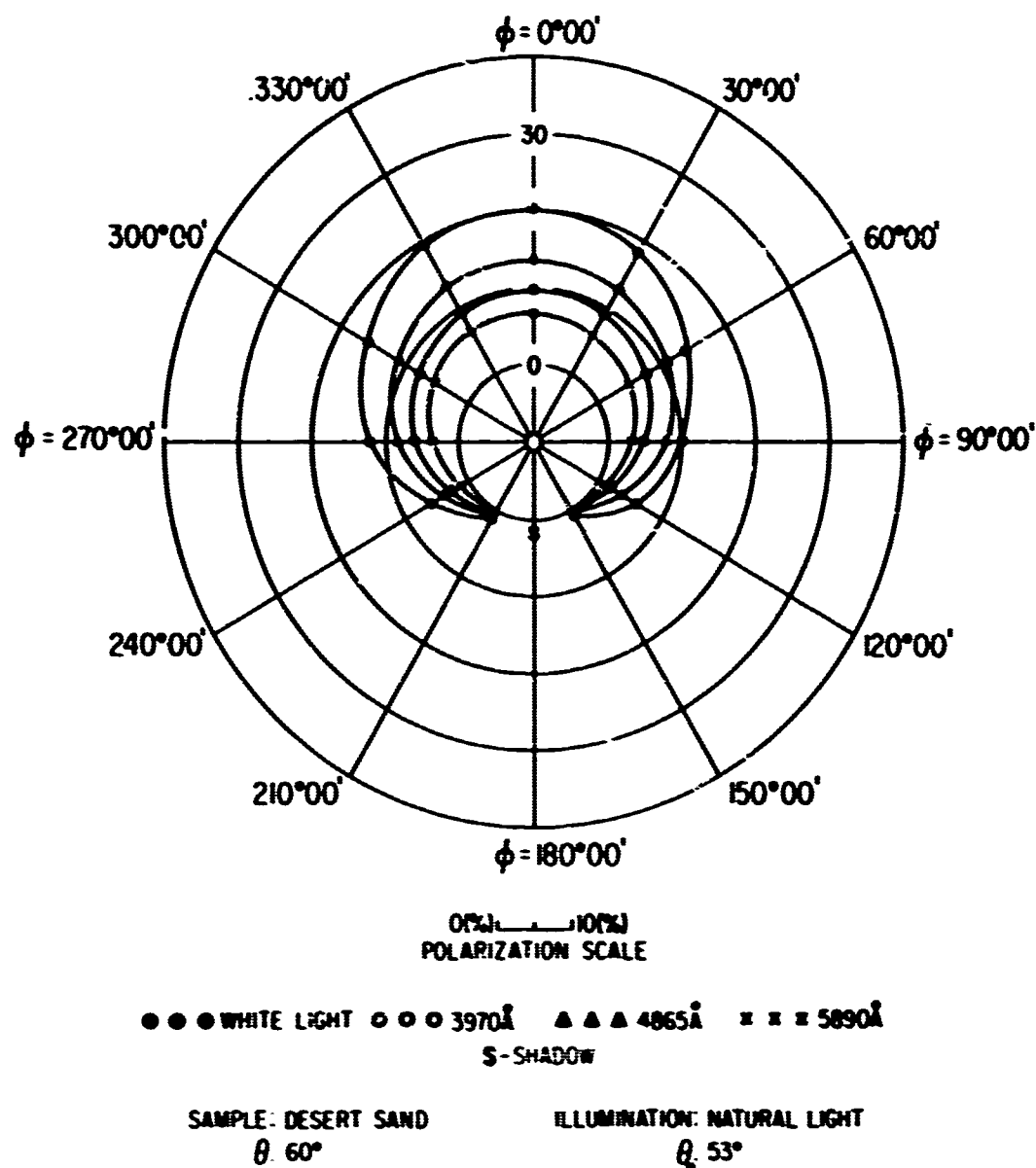


FIG 17. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 4.98 + 4.84 \cos \phi - 0.34 \cos 2\phi + 0.02 \cos 3\phi + 0.14 \cos 4\phi - 0.10 \cos 5\phi \\ + 0.13 \cos 6\phi - 0.34 \sin \phi + 0.02 \sin 2\phi + 0.15 \sin 3\phi + 0.02 \sin 4\phi - 0.11 \sin 5\phi$$

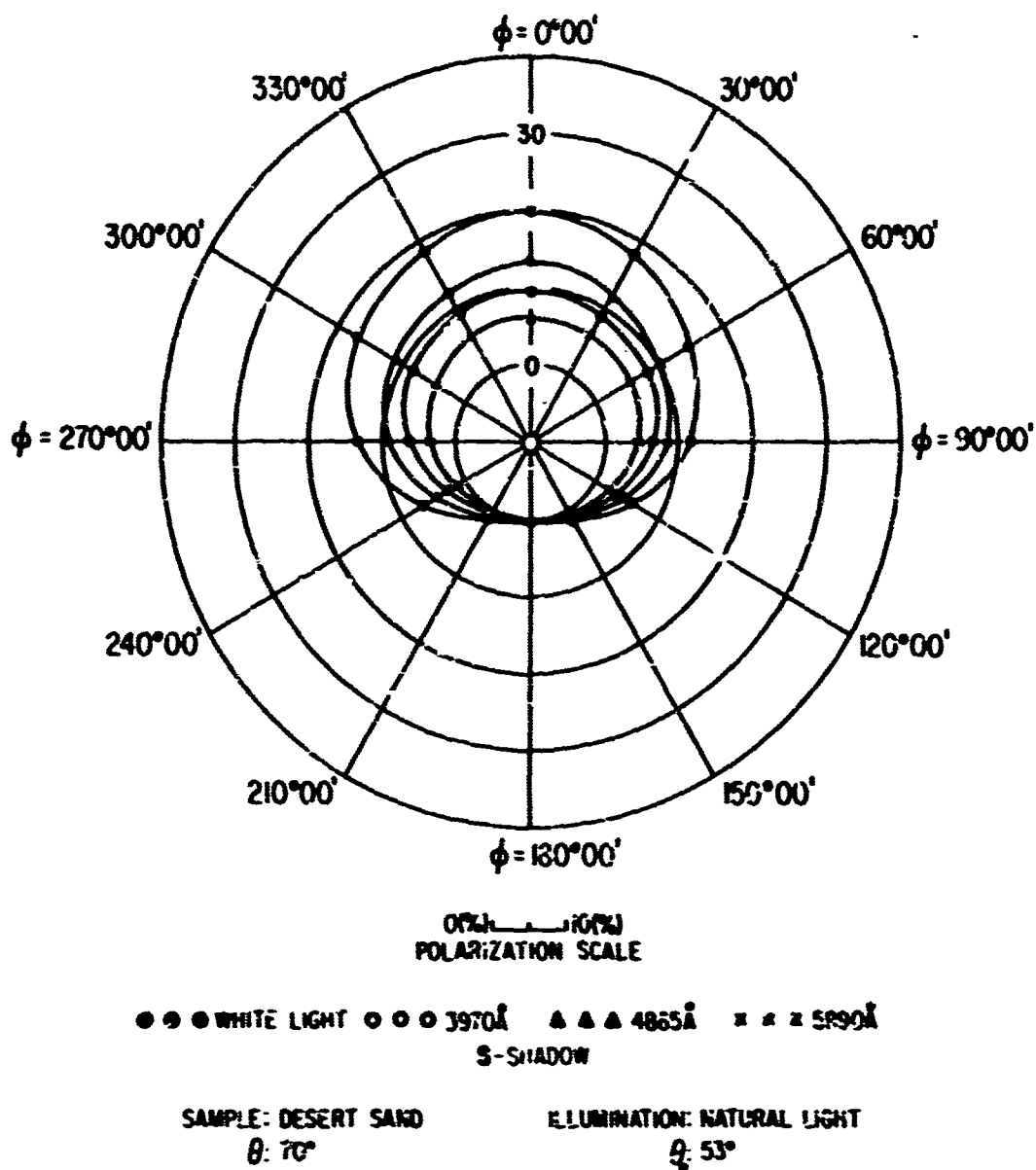


FIG 18. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.10 + 5.07 \cos \phi - 0.54 \cos 2\phi - 0.50 \cos 3\phi + 0.42 \cos 4\phi + 0.28 \cos 5\phi \\
 & - 0.27 \cos 6\phi + 0.40 \sin \phi - 0.62 \sin 2\phi - 0.03 \sin 3\phi + 0.44 \sin 4\phi - 0.44 \sin 5\phi
 \end{aligned}$$

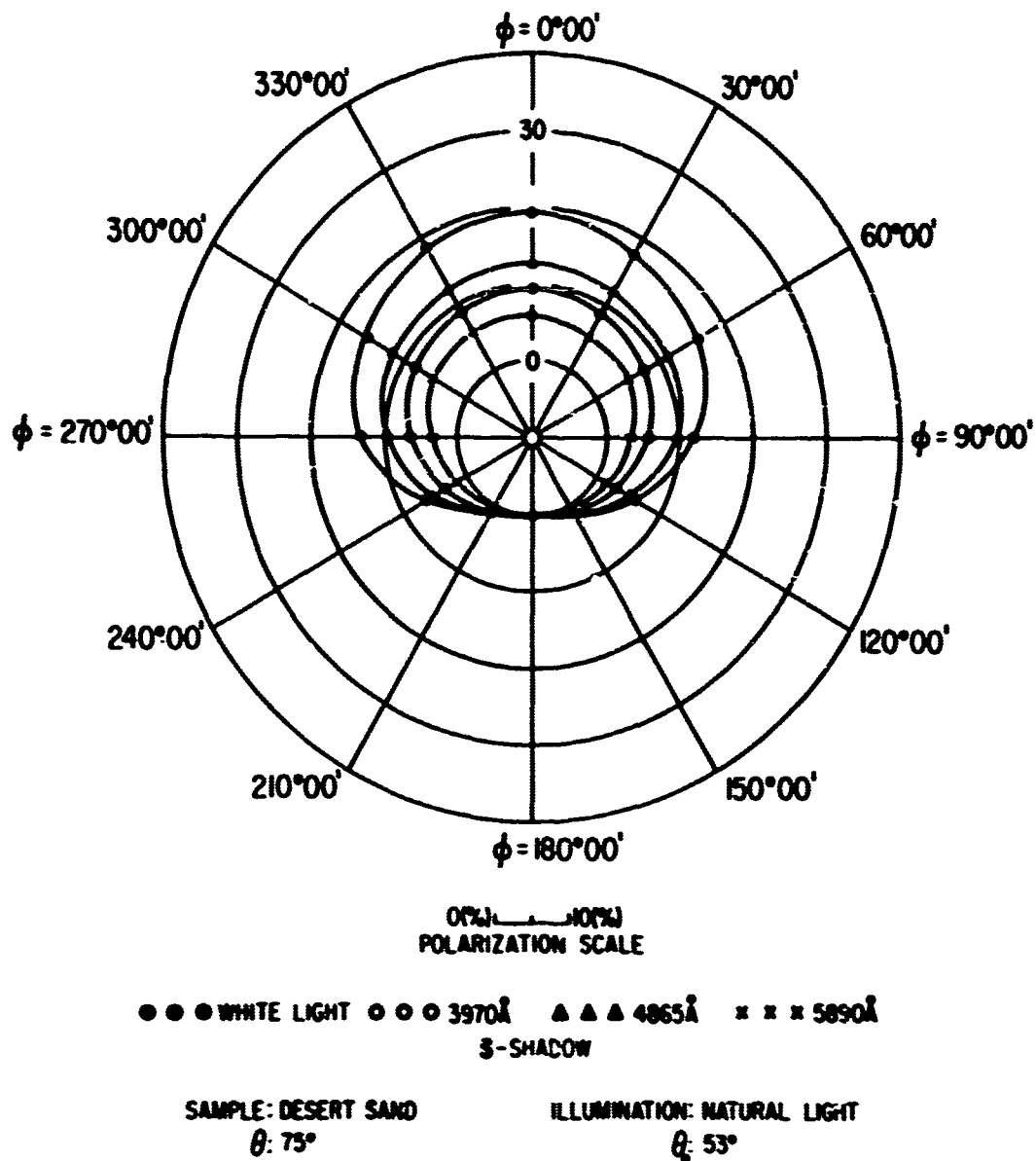


FIG. 19. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 5.23 + 4.47 \cos \varphi - 0.77 \cos 2\varphi + 0.08 \cos 3\varphi + 0.22 \cos 4\varphi - 0.06 \cos 5\varphi \\
 & + 0.43 \cos 6\varphi - 0.22 \sin \varphi - 0.08 \sin 2\varphi - 0.05 \sin 3\varphi + 0.00 \sin 4\varphi - 0.02 \sin 5\varphi
 \end{aligned}$$

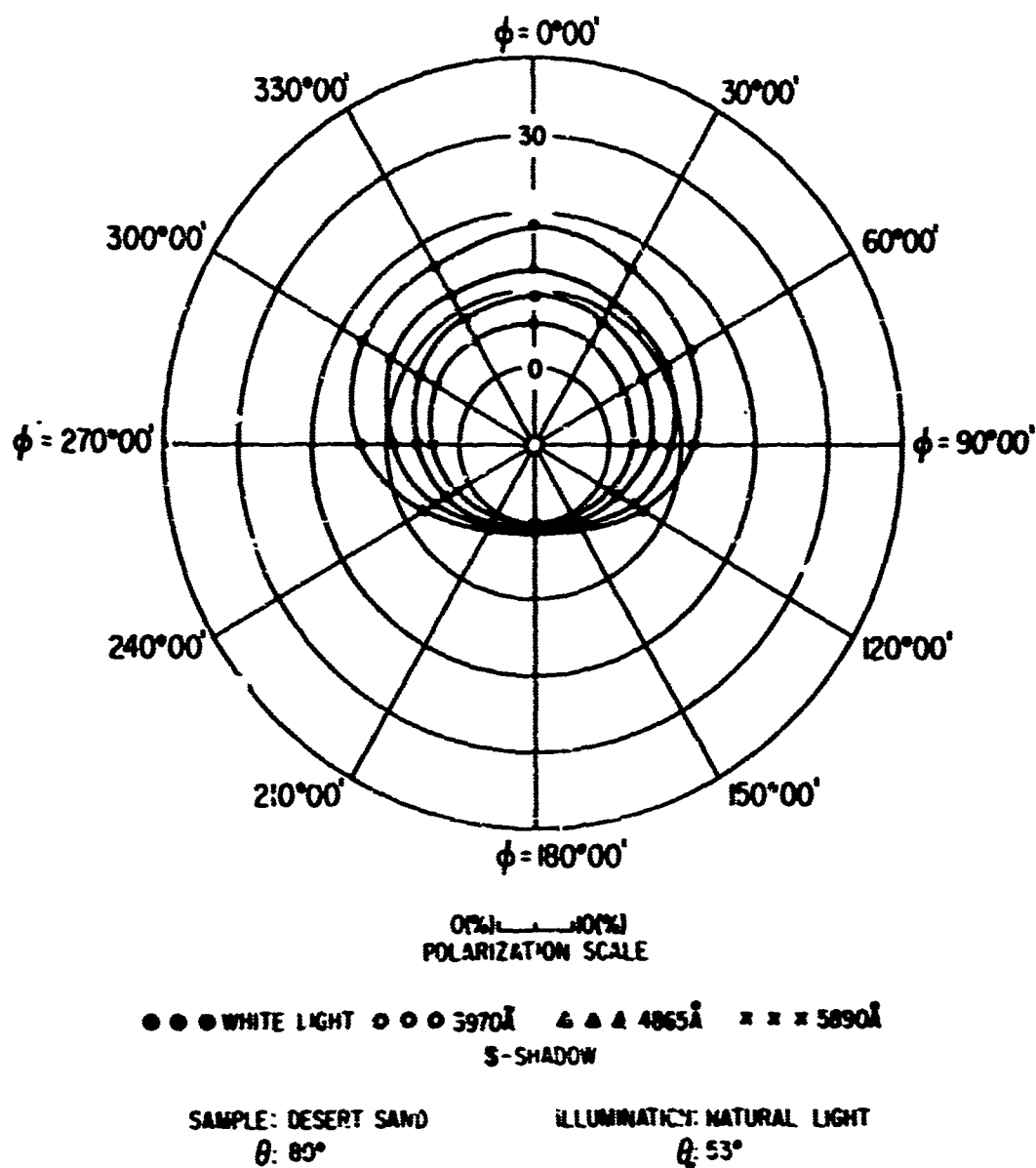


FIG. 20. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.34 + 3.60 \cos \phi - 0.52 \cos 2\phi + 0.07 \cos 3\phi + 0.33 \cos 4\phi + 0.28 \cos 5\phi \\
 & - 0.22 \cos 6\phi - 0.36 \sin \phi + 0.11 \sin 2\phi + 0.02 \sin 3\phi - 0.09 \sin 4\phi + 0.08 \sin 5\phi
 \end{aligned}$$

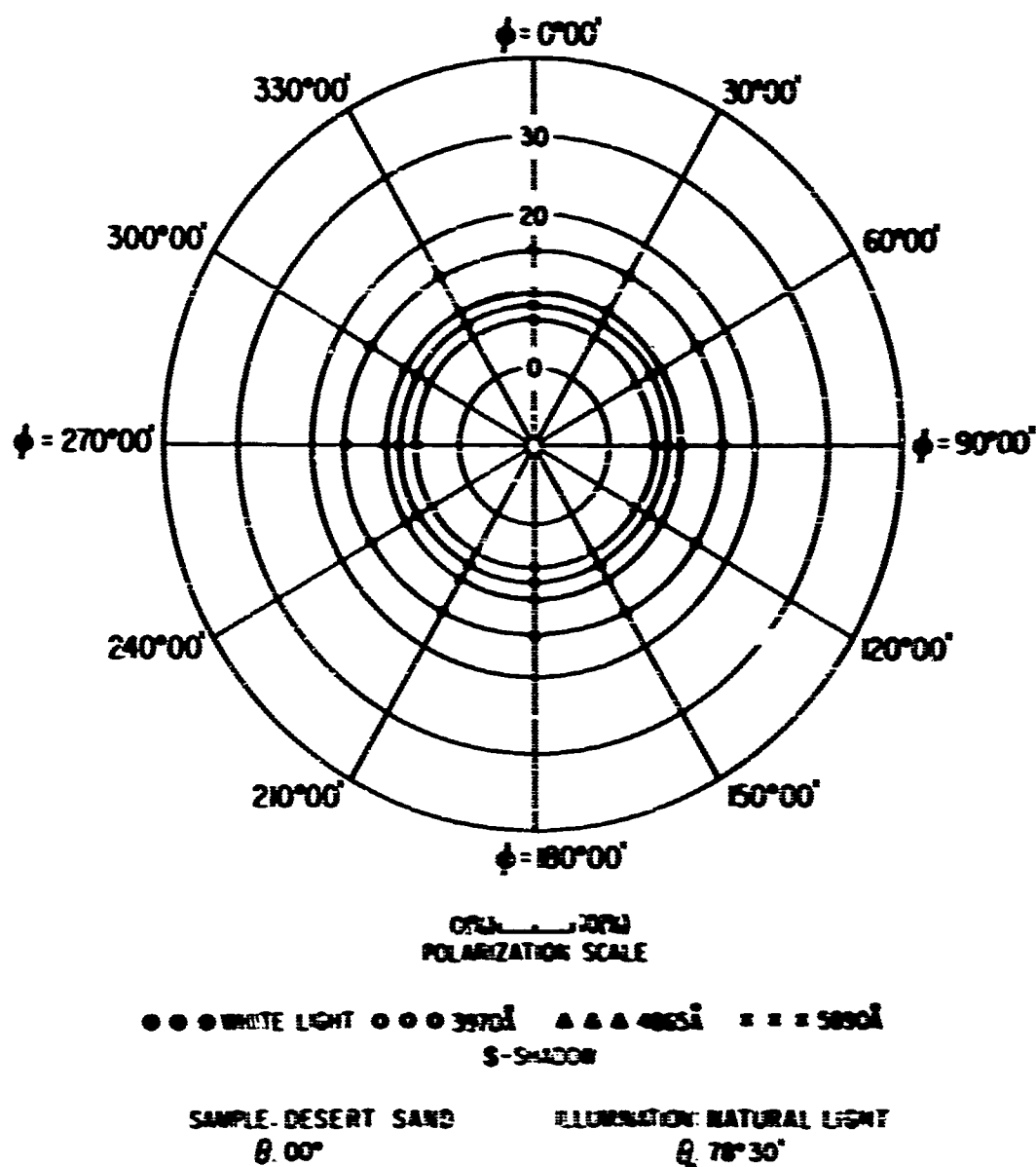
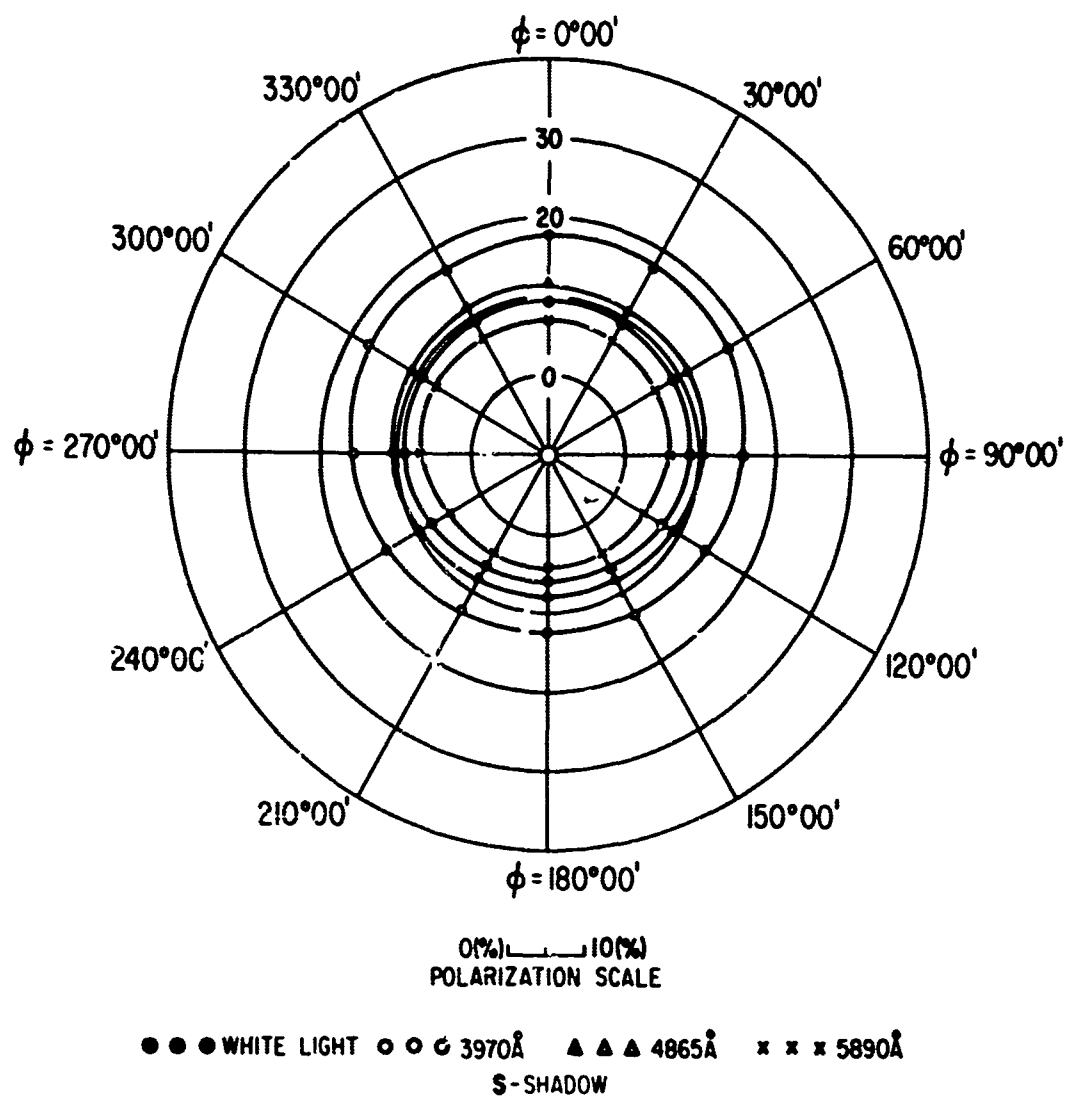


FIG 21. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT



SAMPLE: DESERT SAND
 $\theta: 10^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 78^\circ 30'$

FIG 22. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 7.86 + 1.64 \cos \varphi - 0.07 \cos 2\varphi + 0.00 \cos 3\varphi - 0.07 \cos 4\varphi - 0.04 \cos 5\varphi \\ + 0.15 \cos 6\varphi + 0.00 \sin \varphi - 0.09 \sin 2\varphi + 0.00 \sin 3\varphi - 0.09 \sin 4\varphi + 0.00 \sin 5\varphi$$

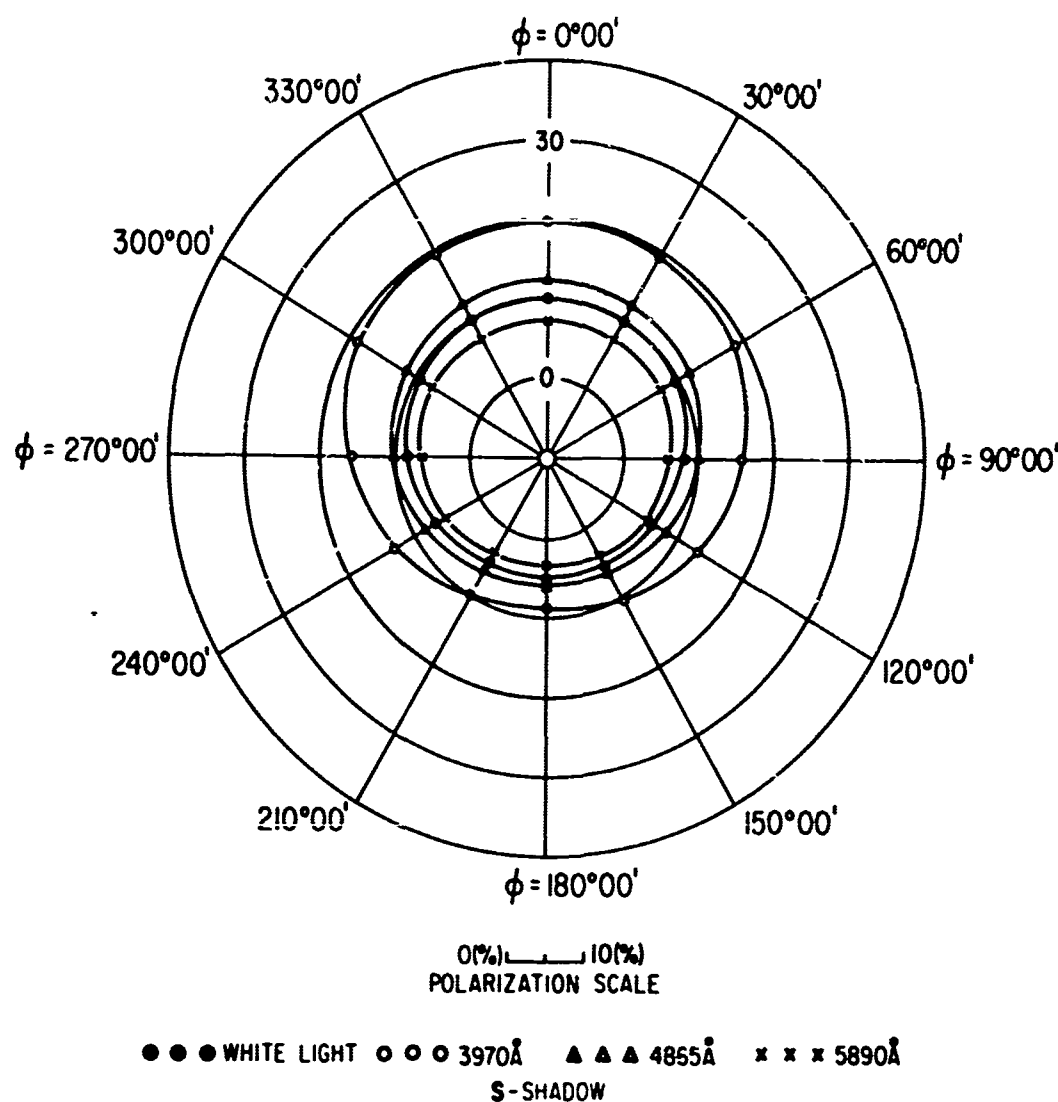
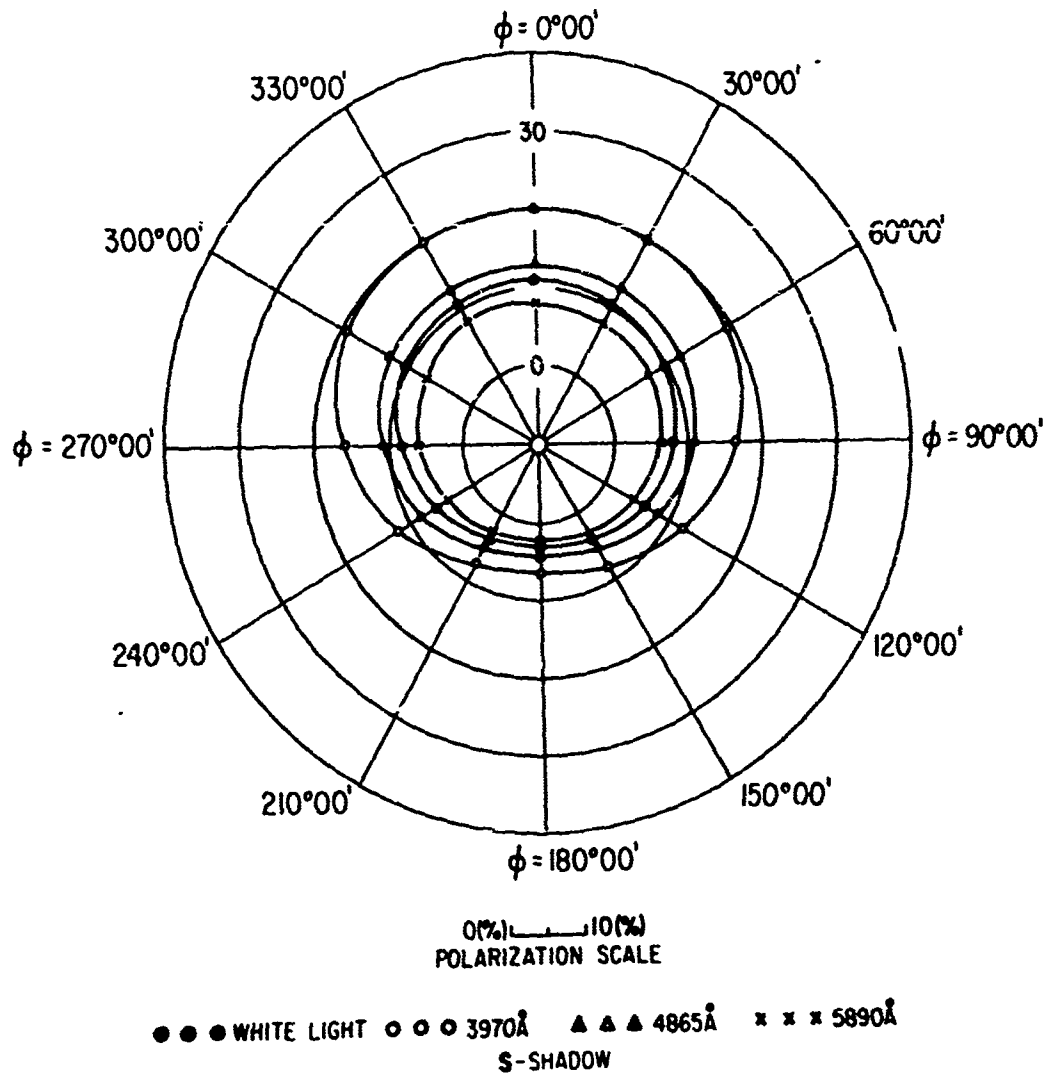


FIG 23. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 7.66 + 2.80 \cos \varphi - 0.01 \cos 2\varphi - 0.23 \cos 3\varphi + 0.14 \cos 4\varphi - 0.06 \cos 5\varphi \\ - 0.2 \cos 6\varphi - 0.01 \sin \varphi + 0.04 \sin 2\varphi - 0.02 \sin 3\varphi - 0.04 \sin 4\varphi - 0.01 \sin 5\varphi$$



SAMPLE: DESERT SAND
 $\theta: 30^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 78^\circ 30'$

FIG. 24. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 7.56 + 4.00 \cos \varphi - 0.30 \cos 2\varphi + 0.27 \cos 3\varphi + 0.03 \cos 4\varphi - 0.13 \cos 5\varphi \\ + 0.20 \cos 6\varphi - 0.02 \sin \varphi + 0.06 \sin 2\varphi - 0.03 \sin 3\varphi - 0.06 \sin 4\varphi - 0.02 \sin 5\varphi$$

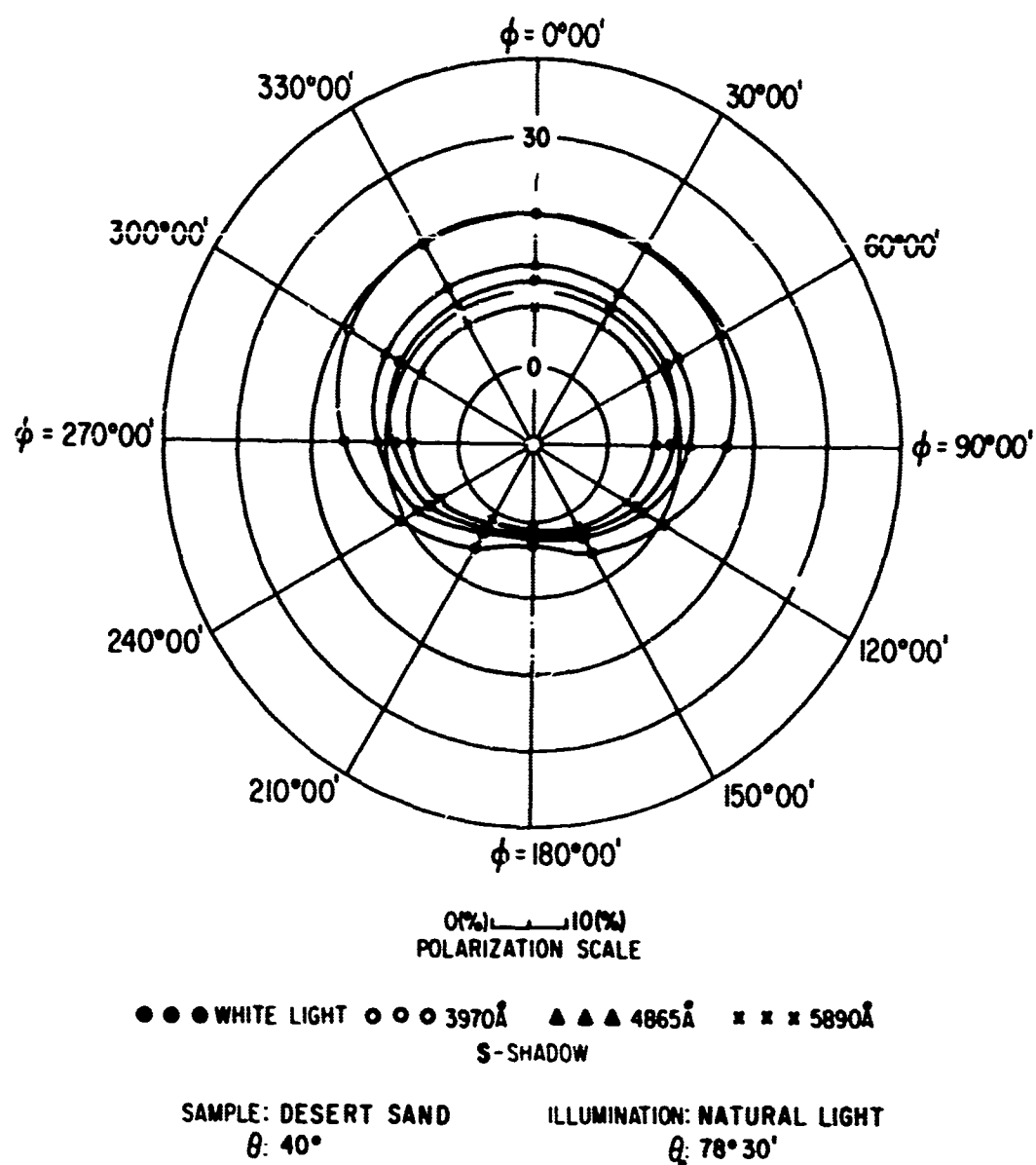


FIG 25. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 7.59 + 4.74 \cos \varphi - 1.01 \cos 2\varphi + 0.00 \cos 3\varphi - 0.19 \cos 4\varphi + 0.26 \cos 5\varphi \\
 & + 0.62 \cos 6\varphi - 0.01 \sin \varphi - 0.07 \sin 2\varphi - 0.02 \sin 3\varphi - 0.07 \sin 4\varphi - 0.01 \sin 5\varphi
 \end{aligned}$$

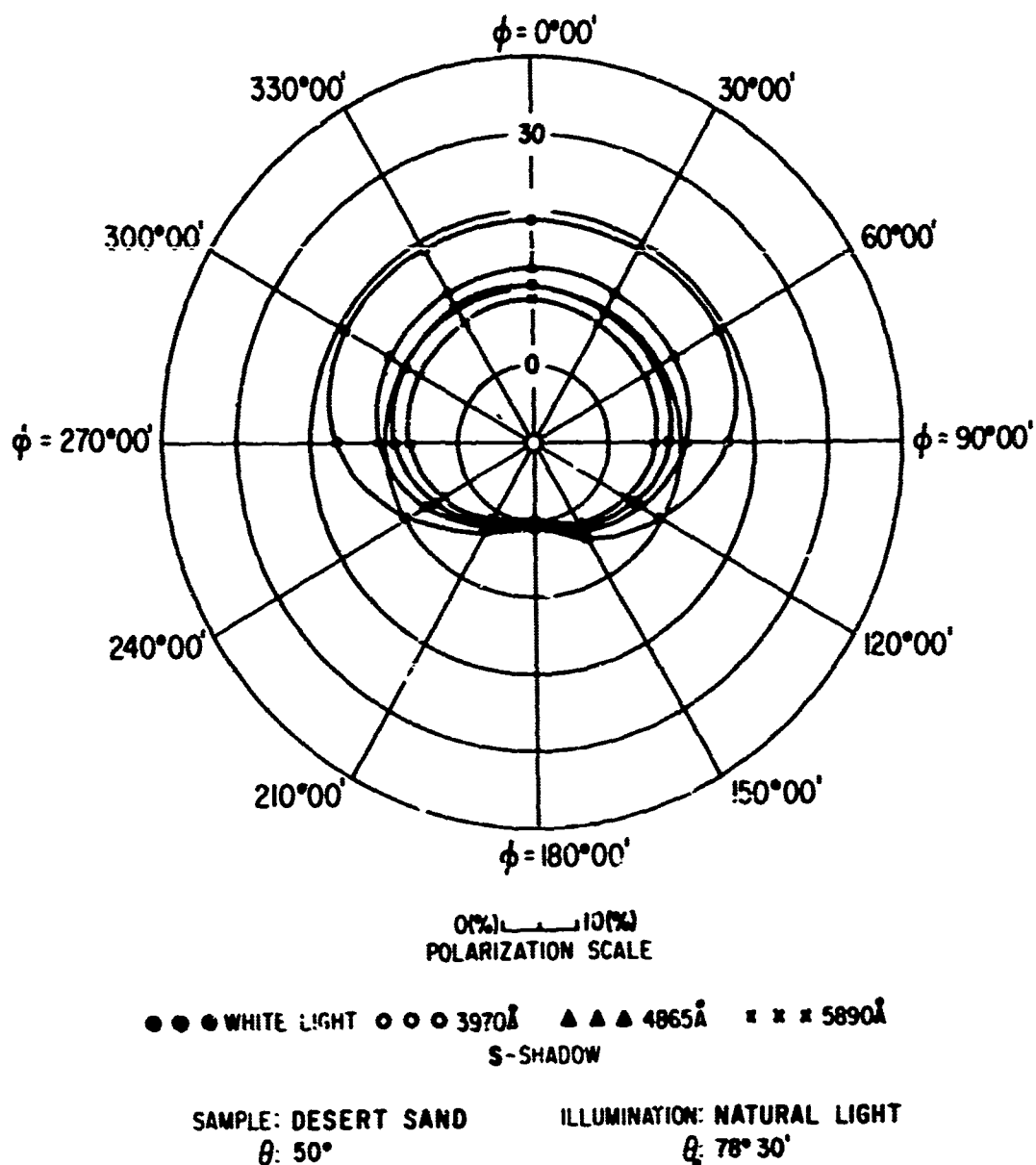
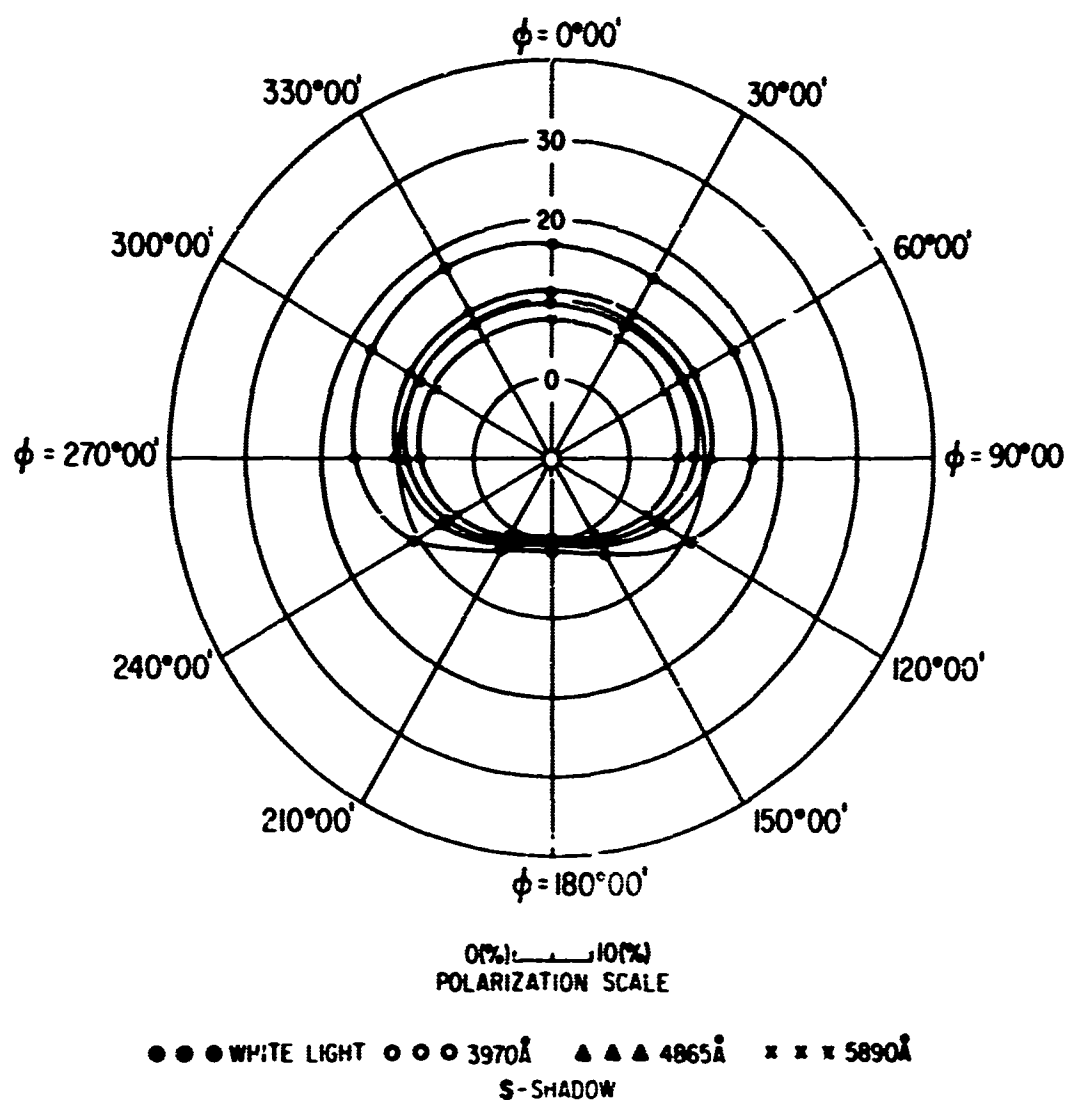


FIG. 26. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.77 + 4.60 \cos \varphi - 1.26 \cos 2\varphi + 0.12 \cos 3\varphi + 0.06 \cos 4\varphi + 0.13 \cos 5\varphi \\
 & - 0.23 \cos 6\varphi - 0.06 \sin \varphi - 0.10 \sin 2\varphi - 0.08 \sin 3\varphi - 0.10 \sin 4\varphi + 0.02 \sin 5\varphi
 \end{aligned}$$



SAMPLE: DESERT SAND
 $\theta: 60^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 78^\circ 30'$

FIG 27. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.83 + 4.14 \cos \varphi - 1.99 \cos 2\varphi + 0.25 \cos 3\varphi + 0.22 \cos 4\varphi - 0.04 \cos 5\varphi \\
 & + 0.31 \cos 5\varphi - 0.04 \sin \varphi - 0.16 \sin 2\varphi - 0.08 \sin 3\varphi - 0.16 \sin 4\varphi + 0.15 \sin 5\varphi
 \end{aligned}$$

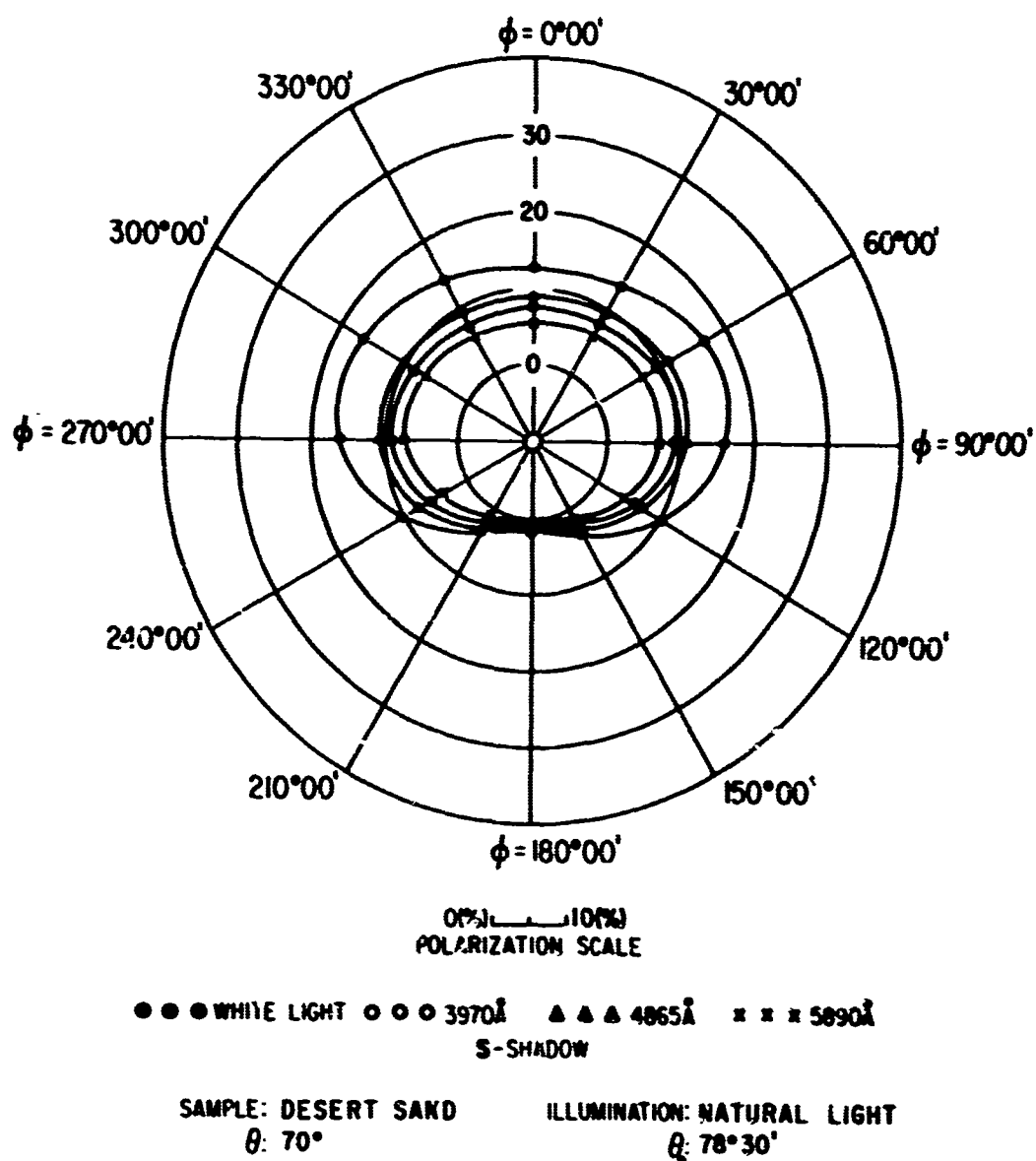
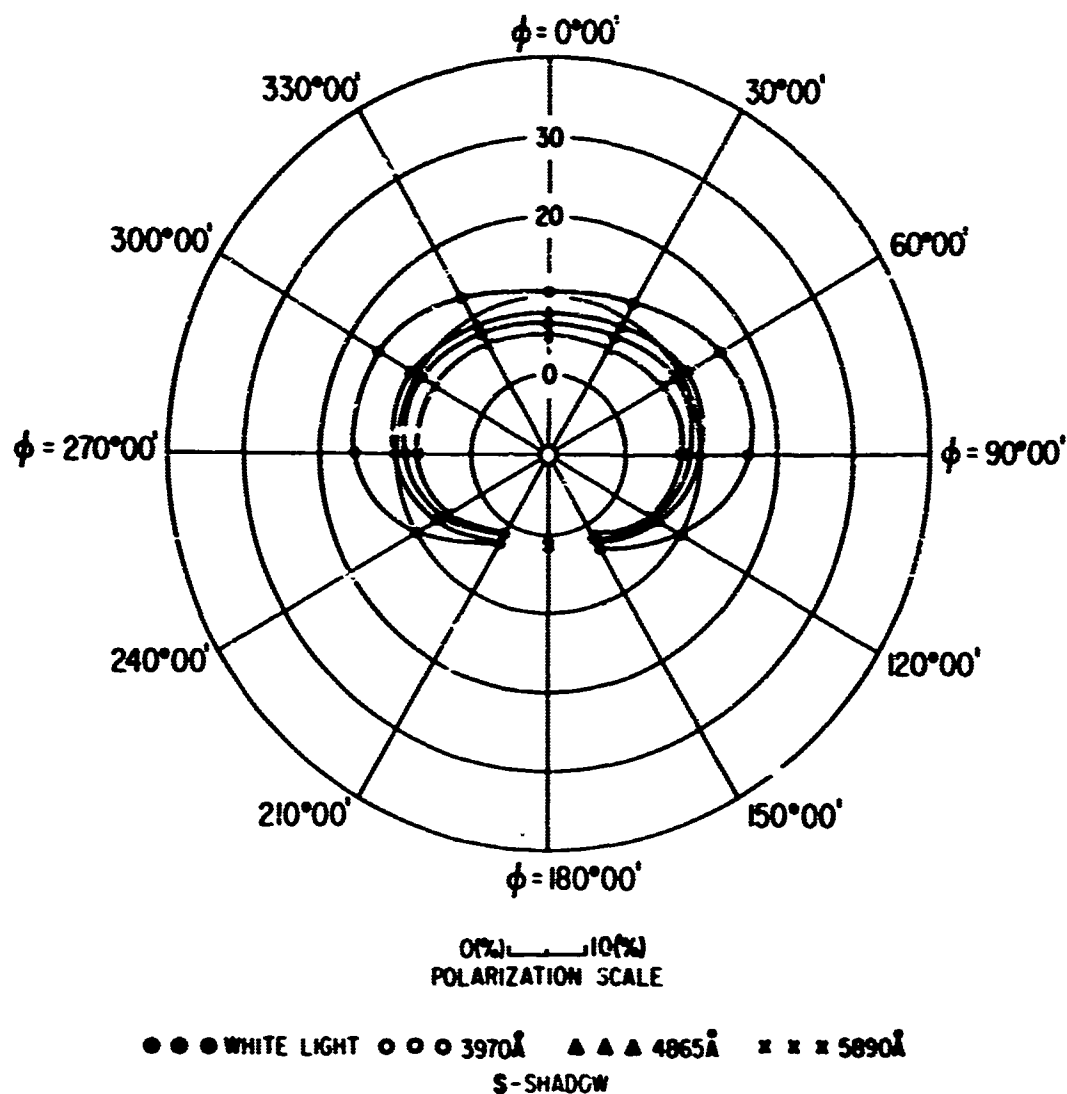


FIG 28. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.51 + 3.24 \cos \varphi - 2.45 \cos 2\varphi - 0.02 \cos 3\varphi + 0.32 \cos 4\varphi - 0.17 \cos 5\varphi \\
 & + 0.35 \cos 6\varphi - 0.03 \sin \varphi - 0.06 \sin 2\varphi - 0.07 \sin 3\varphi - 0.06 \sin 4\varphi - 0.03 \sin 5\varphi
 \end{aligned}$$

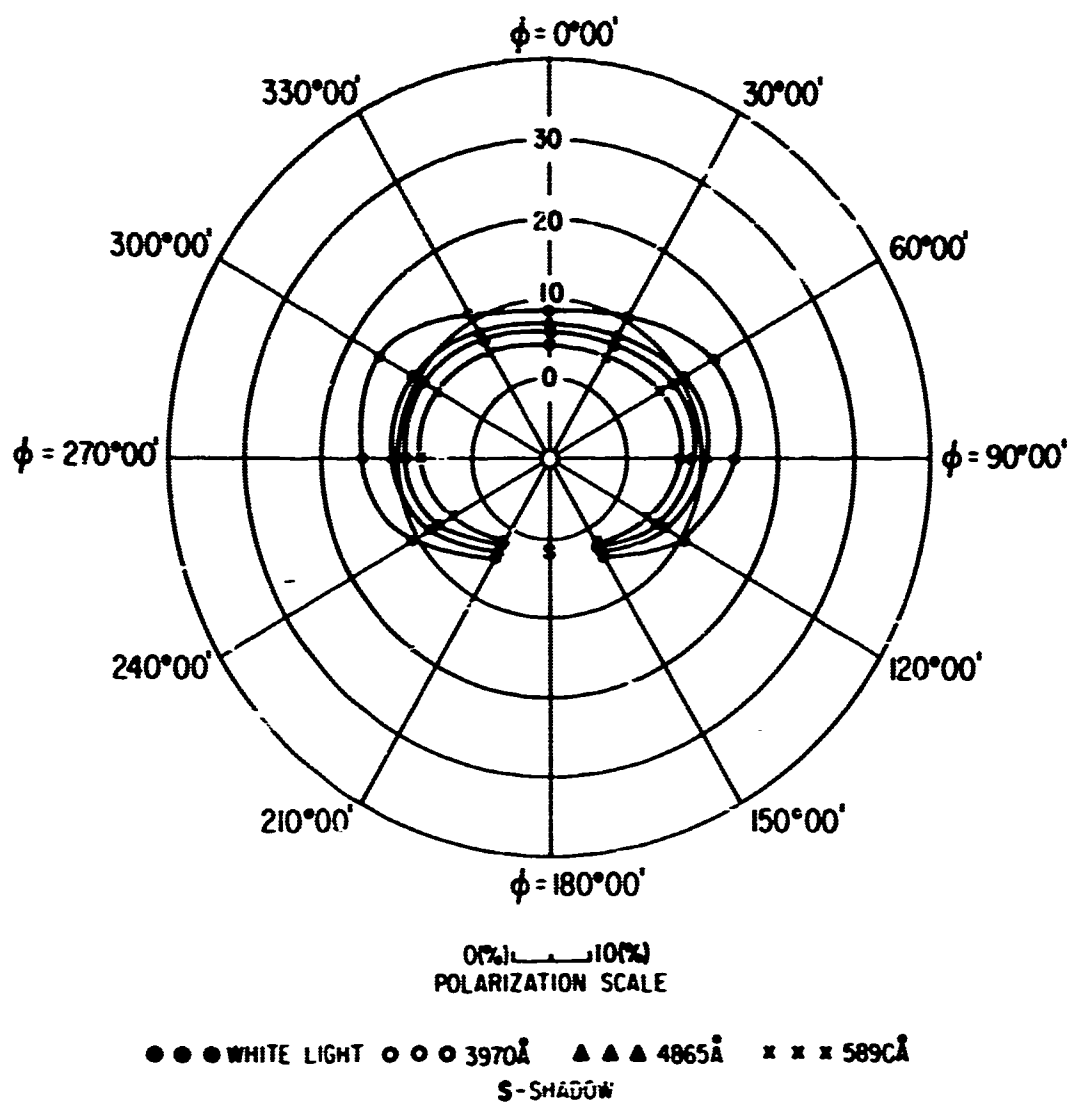


SAMPLE: DESERT SAND
 $\theta: 75^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta: 78^\circ 30'$

FIG 29. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 6.02 + 3.31 \cos \varphi - 2.37 \cos 2\varphi - 0.62 \cos 3\varphi - 0.10 \cos 4\varphi + 0.09 \cos 5\varphi \\ + 0.18 \cos 6\varphi - 0.07 \sin \varphi - 0.12 \sin 2\varphi - 0.03 \sin 3\varphi - 0.12 \sin 4\varphi - 0.07 \sin 5\varphi$$



SAMPLE: DESERT SAND
 θ 80°

ILLUMINATION: NATURAL LIGHT
 θ_i 78° 30'

FIG 30. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 6.11 + 2.35 \cos \varphi - 2.76 \cos 2\varphi - 0.15 \cos 3\varphi - 0.11 \cos 4\varphi - 0.22 \cos 5\varphi \\ + 0.72 \cos 6\varphi - 0.08 \sin \varphi - 0.13 \sin 2\varphi - 0.15 \sin 3\varphi - 0.13 \sin 4\varphi - 0.08 \sin 5\varphi$$

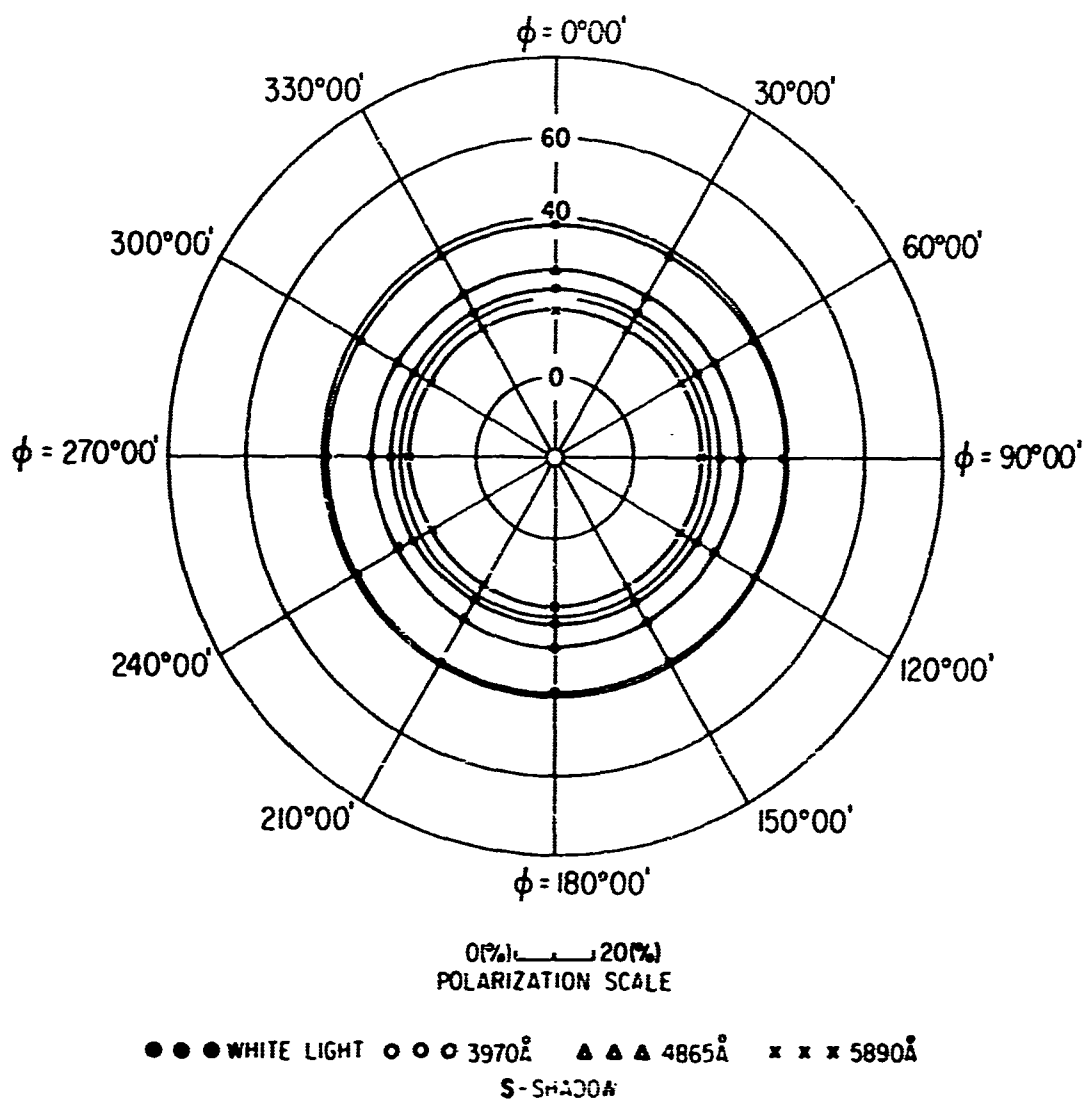


FIG 31. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 22.52 - 0.06 \cos \phi - 0.25 \cos 2\phi - 0.22 \cos 3\phi + 0.43 \cos 4\phi - 0.03 \cos 5\phi \\
 & + 0.20 \cos 6\phi + 0.33 \sin \phi + 0.00 \sin 2\phi + 0.08 \sin 3\phi - 0.32 \sin 4\phi - 0.05 \sin 5\phi
 \end{aligned}$$

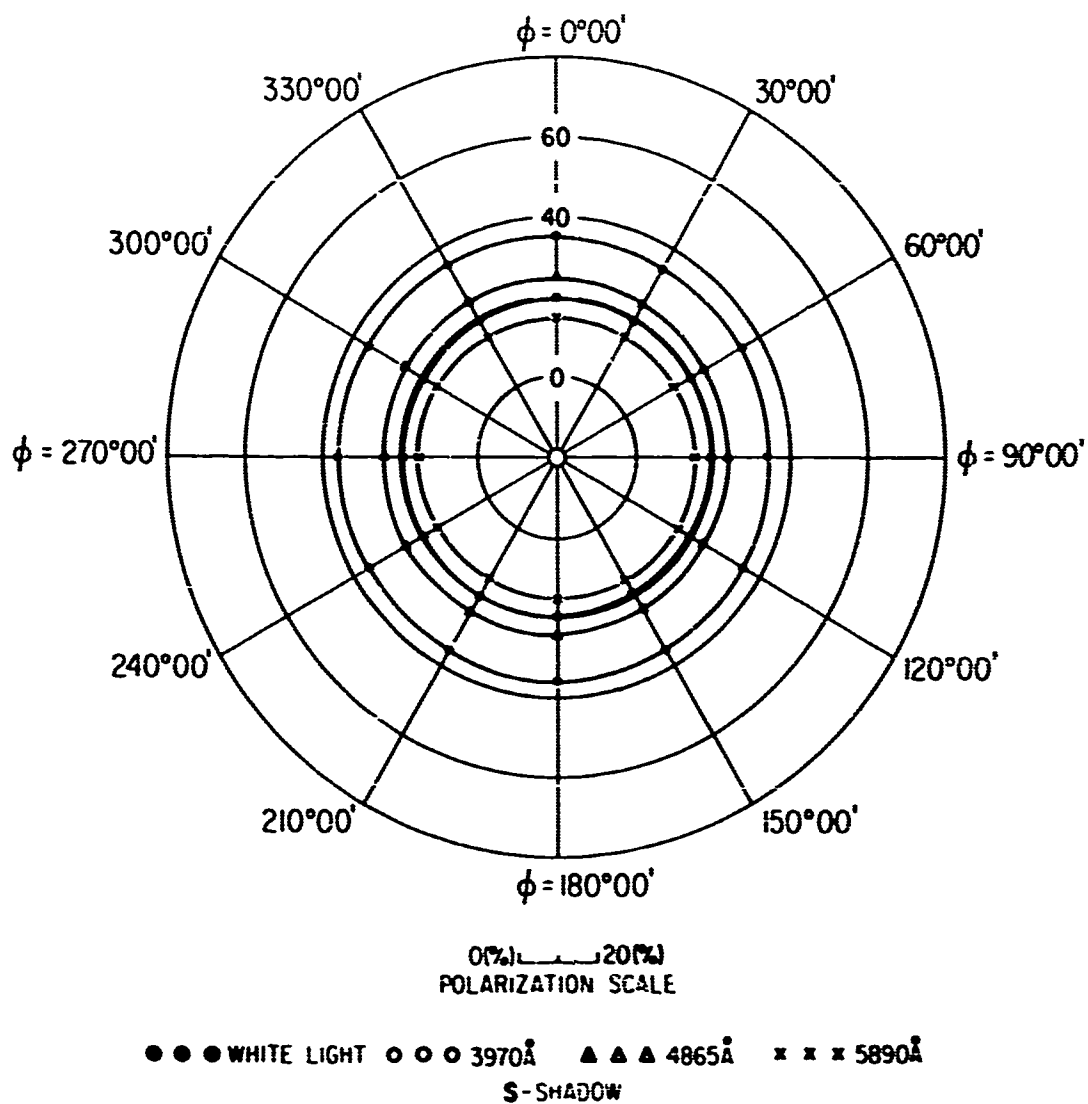


FIG 32. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 19.80 - 0.18 \cos \varphi + 0.67 \cos 2\varphi + 0.17 \cos 3\varphi + 0.30 \cos 4\varphi - 0.04 \cos 5\varphi \\ - 0.07 \cos 6\varphi + 0.08 \sin \varphi + 0.15 \sin 2\varphi + 0.00 \sin 3\varphi - 0.12 \sin 4\varphi - 0.13 \sin 5\varphi$$

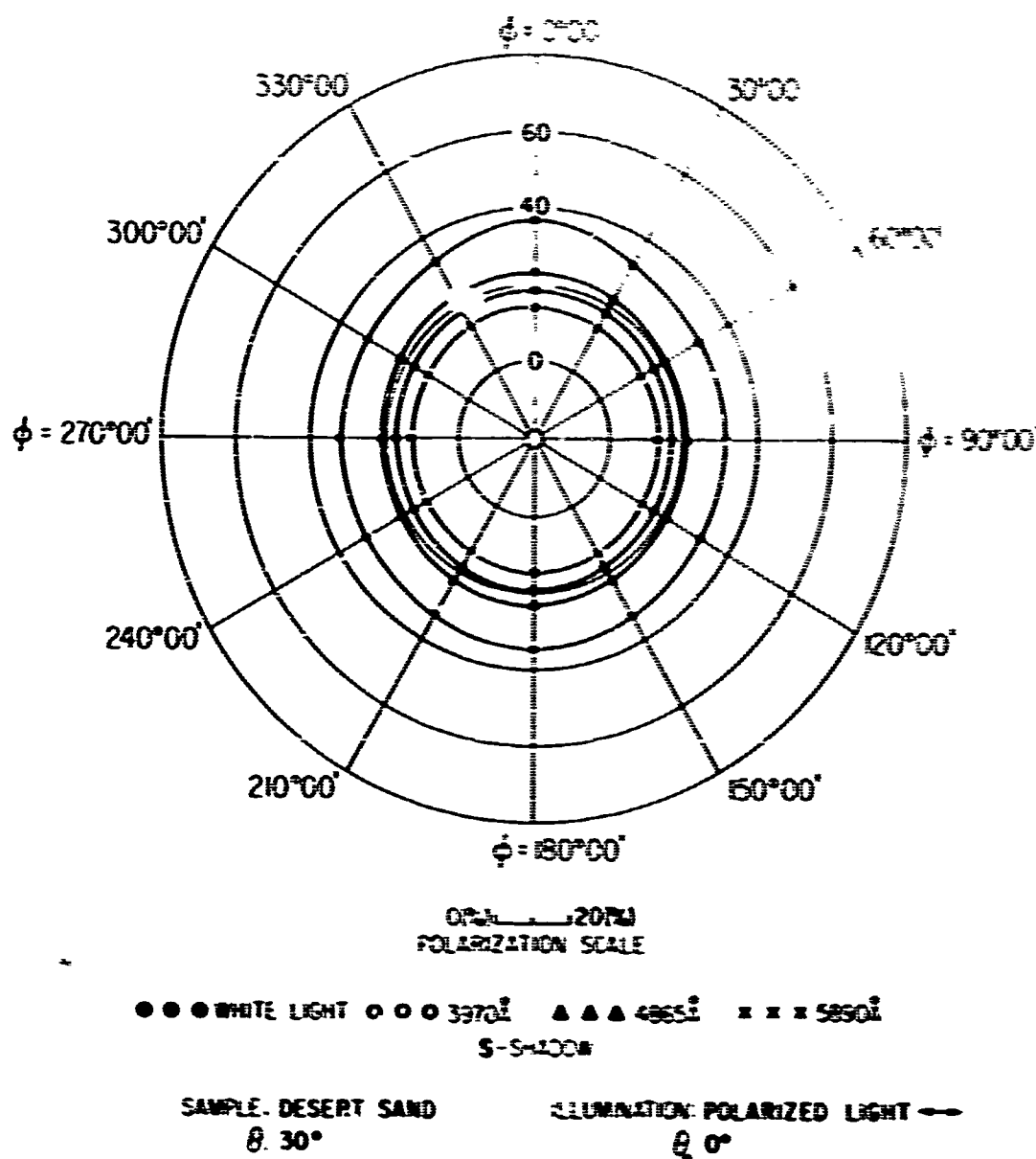


FIG 33. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 17.93 - 0.16 \cos \phi + 1.32 \cos 2\phi + 0.02 \cos 3\phi + 0.32 \cos 4\phi - 0.02 \cos 5\phi \\ + 0.18 \cos 6\phi - 0.03 \sin \phi - 0.17 \sin 2\phi - 0.08 \sin 3\phi - 0.12 \sin 4\phi - 0.20 \sin 5\phi$$

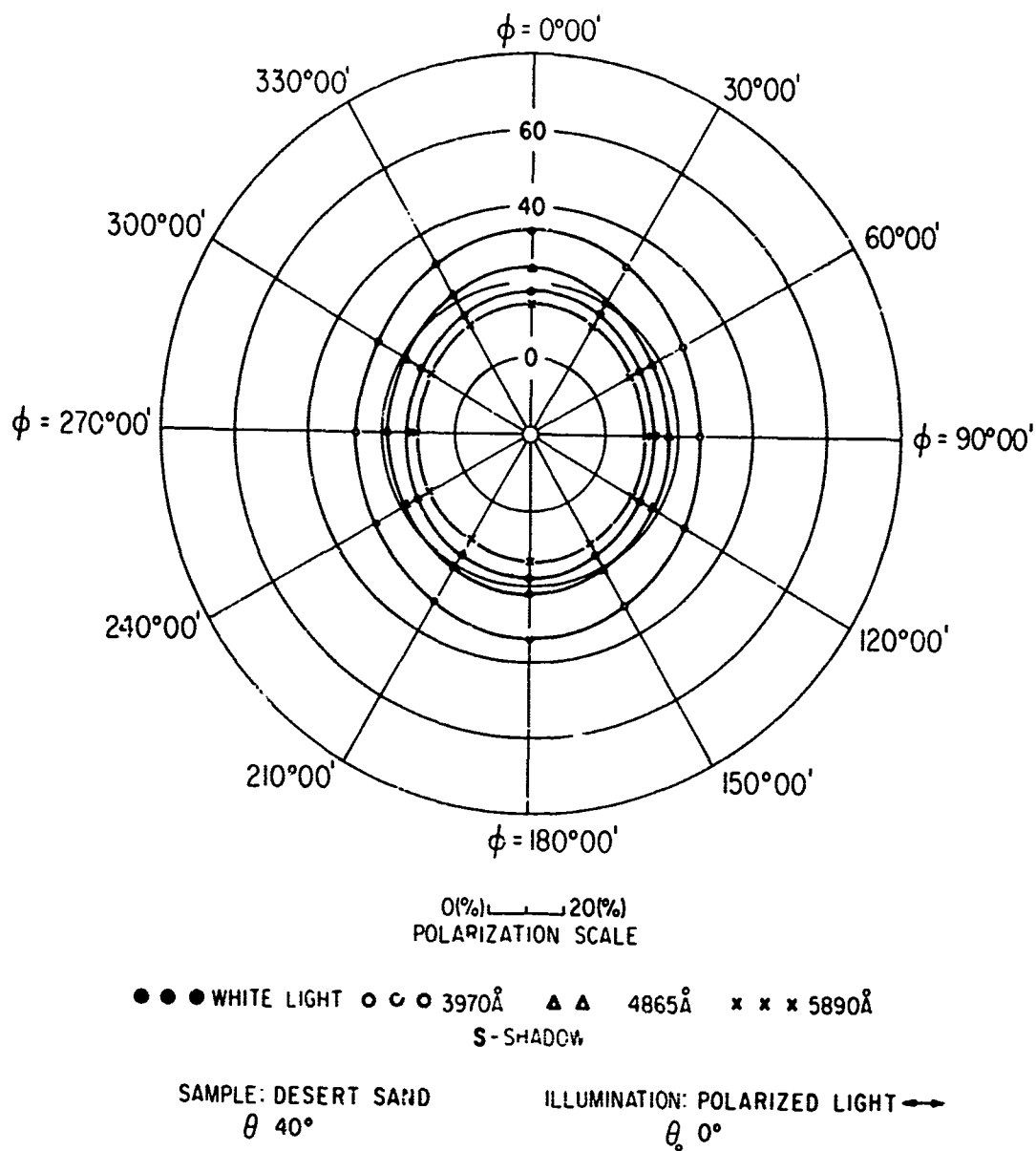
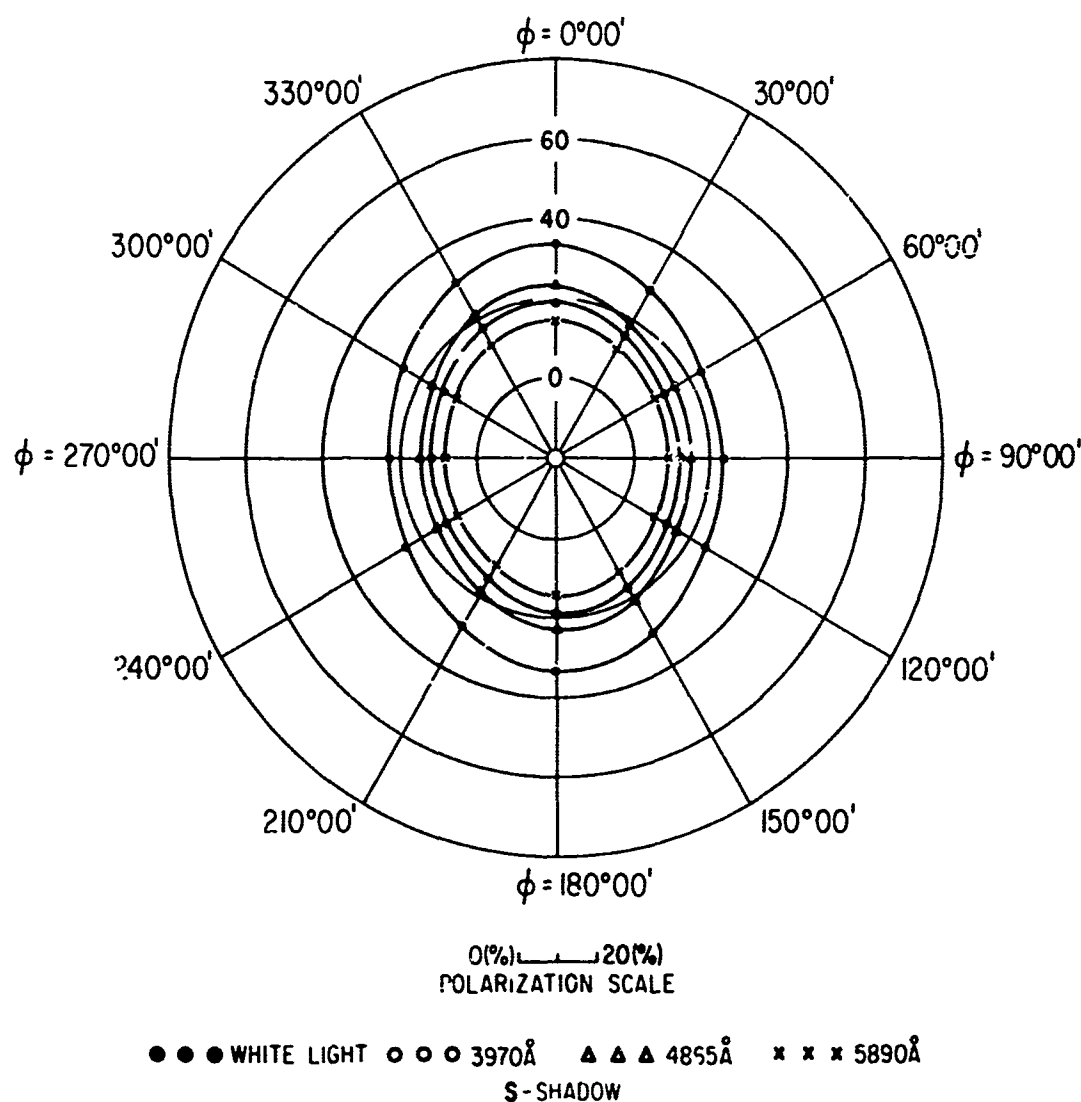


FIG 34. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 16.08 + 0.13 \cos \varphi + 3.12 \cos 2\varphi - 0.05 \cos 3\varphi + 0.10 \cos 4\varphi - 0.40 \cos 5\varphi \\ + 0.26 \cos 6\varphi + 0.53 \sin \varphi + 0.07 \sin 2\varphi - 0.43 \sin 3\varphi + 0.09 \sin 4\varphi + 0.68 \sin 5\varphi$$



SAMPLE: DESERT SAND
 $\theta: 50^\circ$

ILLUMINATION: POLARIZED LIGHT \longleftrightarrow
 $\theta: 0^\circ$

FIG 35. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 15.06 + 0.97 \cos \varphi + 3.53 \cos 2\varphi - 0.02 \cos 3\varphi + 0.97 \cos 4\varphi - 0.10 \cos 5\varphi \\ - 0.10 \cos 6\varphi - 0.03 \sin \varphi - 0.72 \sin 2\varphi + 0.00 \sin 3\varphi - 0.43 \sin 4\varphi + 0.03 \sin 5\varphi$$

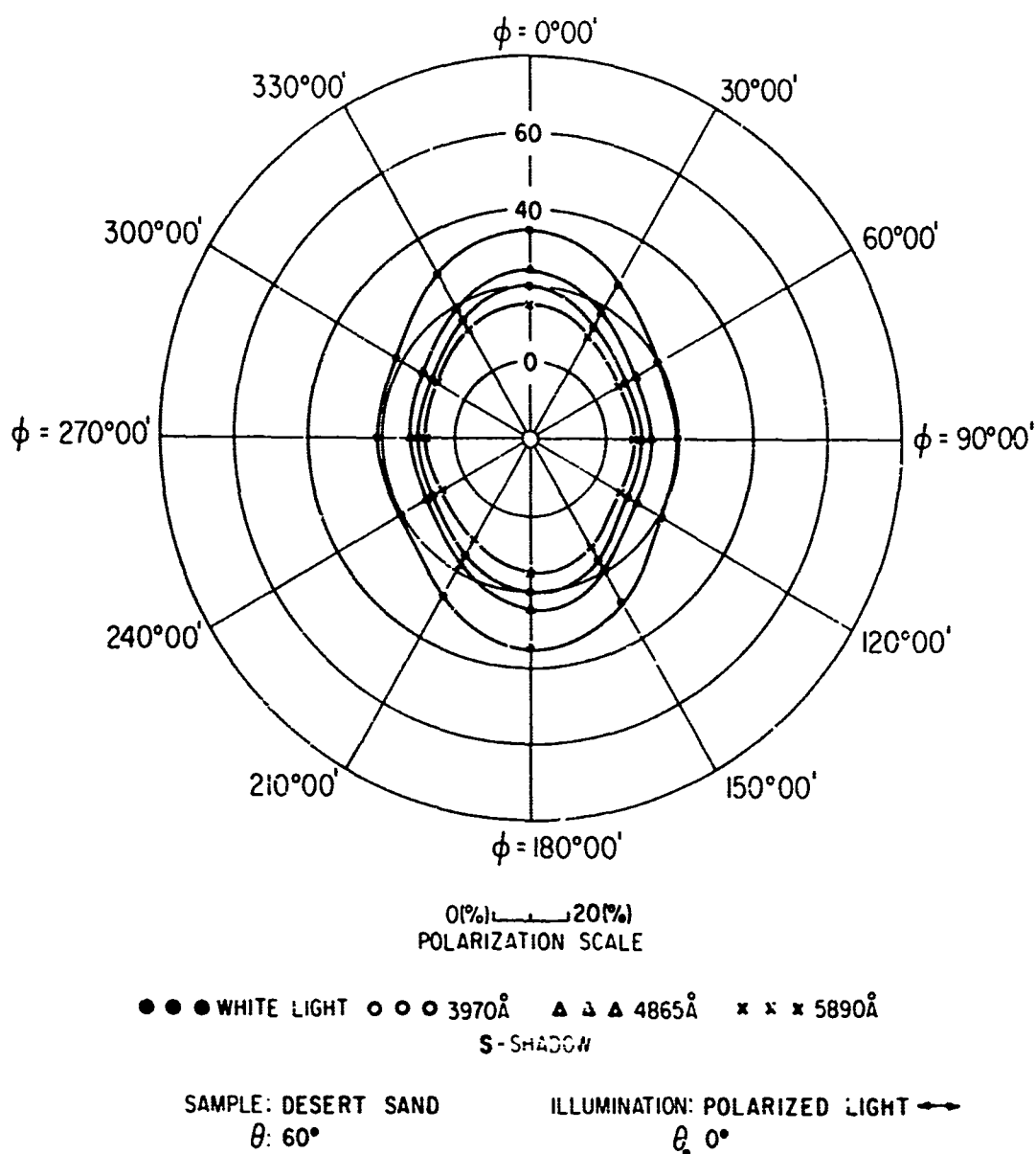
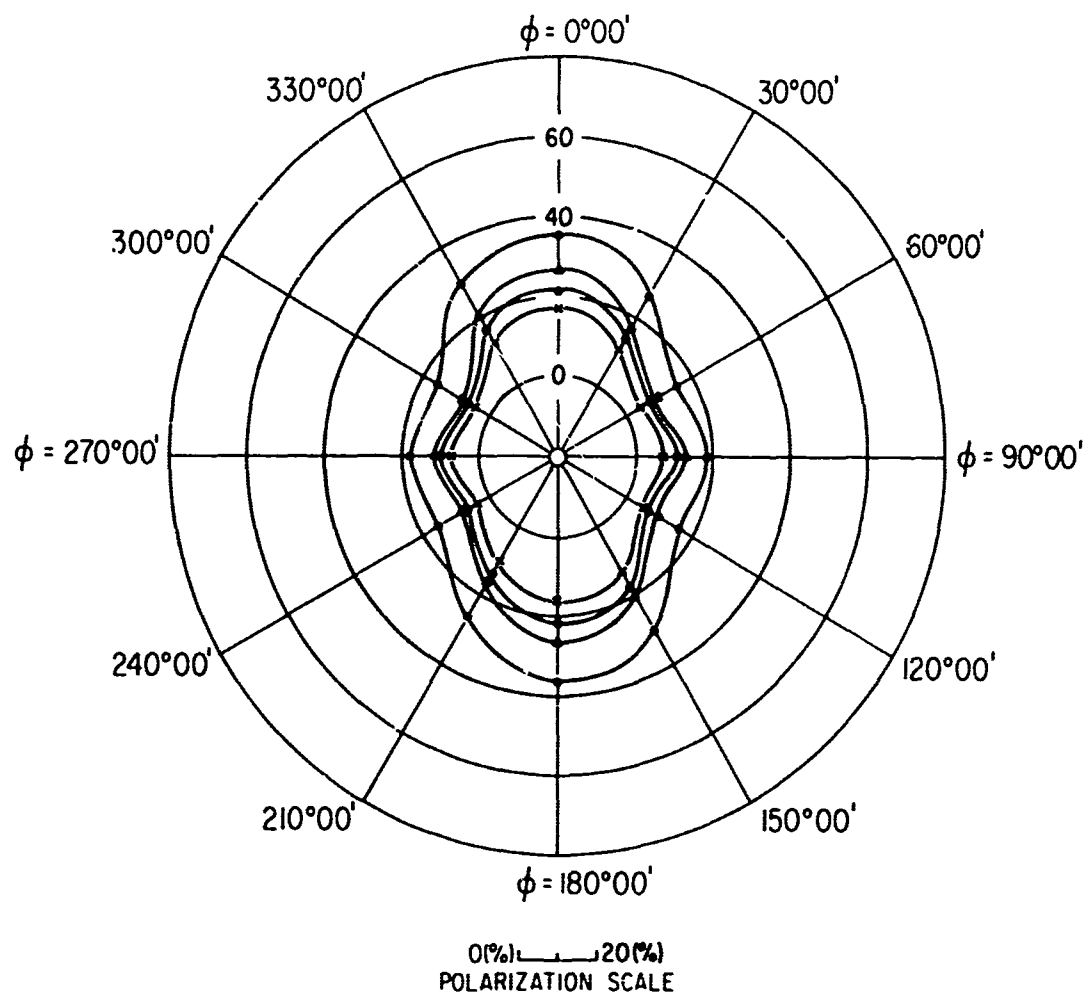


FIG 36. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 13.99 - 0.02 \cos \varphi + 4.59 \cos 2\varphi + 0.02 \cos 3\varphi + 0.71 \cos 4\varphi + 0.10 \cos 5\varphi \\ - 0.83 \cos 6\varphi - 0.16 \sin \varphi - 0.82 \sin 2\varphi + 0.03 \sin 3\varphi + 0.54 \sin 4\varphi + 0.10 \sin 5\varphi$$



● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
 S-SHADOW

SAMPLE: DESERT SAND
 $\theta: 70^\circ$

ILLUMINATION: POLARIZED LIGHT \longleftrightarrow
 $\theta_i: 0^\circ$

FIG 37. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 13.18 - 0.10 \cos \phi + 6.63 \cos 2\phi + 0.05 \cos 3\phi - 2.97 \cos 4\phi - 0.10 \cos 5\phi \\
 & - 1.90 \cos 6\phi - 0.08 \sin \phi - 1.01 \sin 2\phi - 0.12 \sin 3\phi - 0.78 \sin 4\phi - 0.03 \sin 5\phi
 \end{aligned}$$

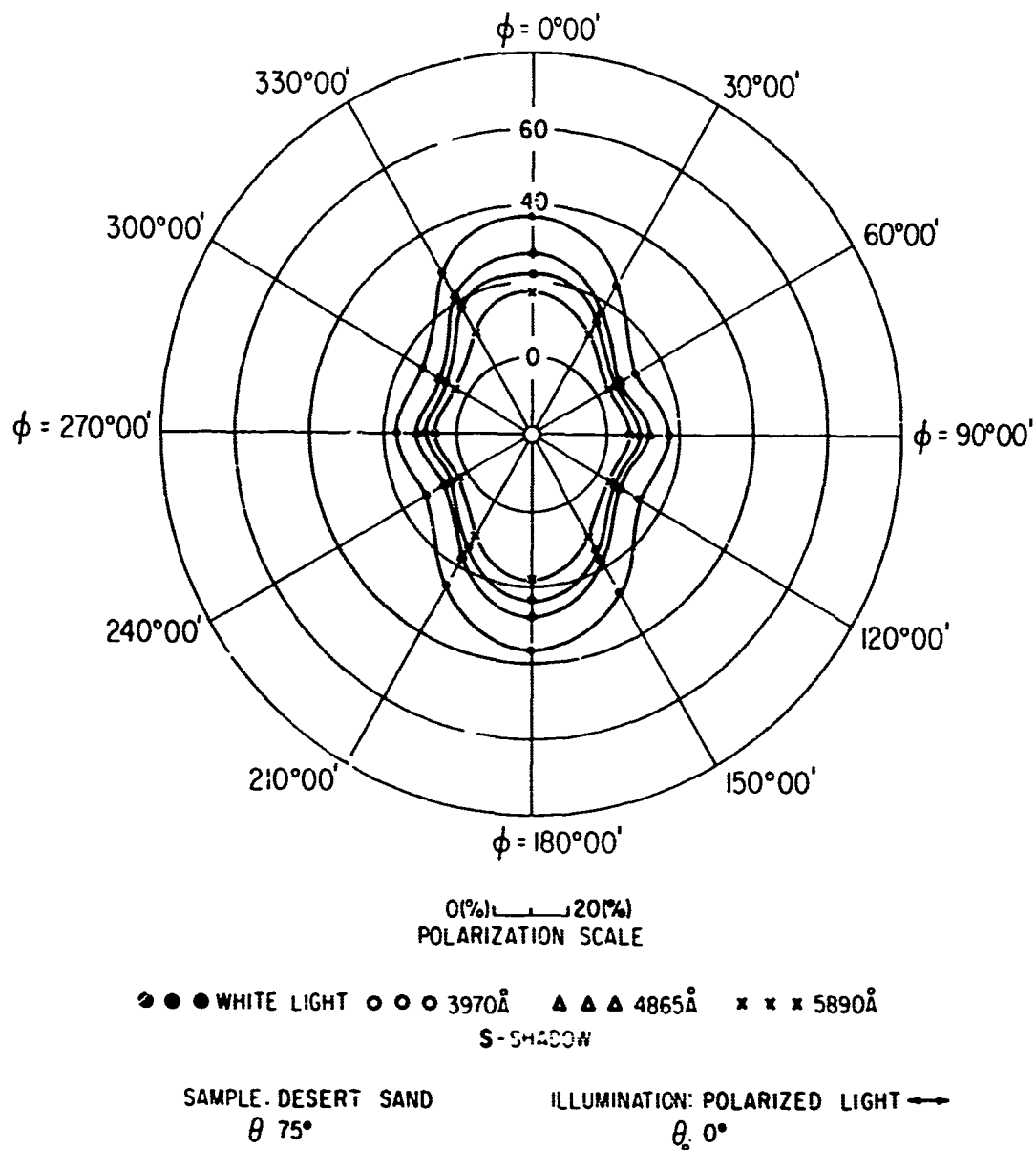


FIG 38. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 12.87 + 1.52 \cos \varphi + 6.97 \cos 2\varphi + 0.97 \cos 3\varphi + 1.68 \cos 4\varphi + 0.16 \cos 5\varphi \\
 & - 3.50 \cos 6\varphi + 0.22 \sin \varphi - 0.32 \sin 2\varphi + 0.80 \sin 3\varphi - 0.46 \sin 4\varphi + 0.42 \sin 5\varphi
 \end{aligned}$$

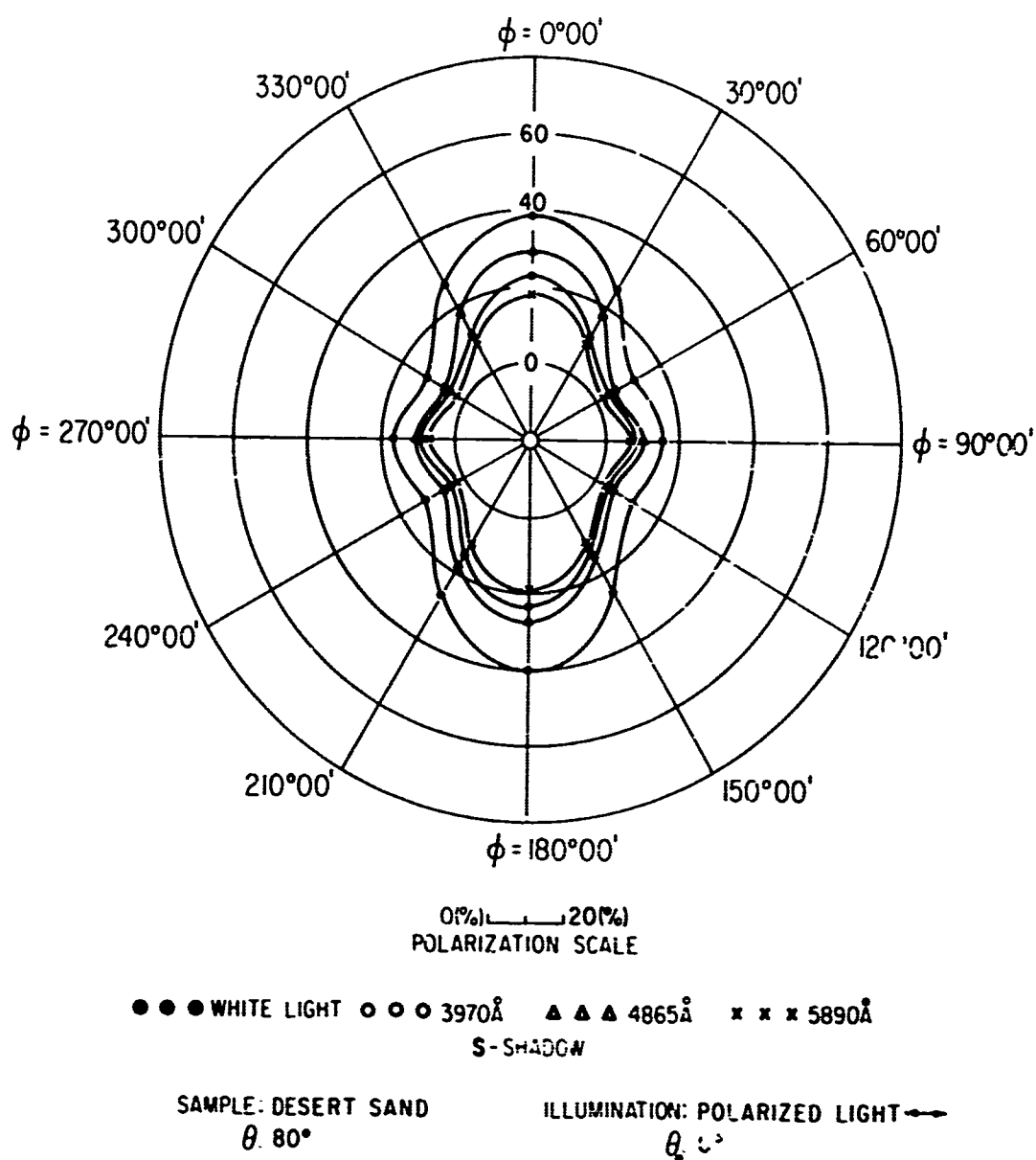


FIG 39. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 13.68 + 0.88 \cos \varphi + 8.70 \cos 2\varphi + 0.18 \cos 3\varphi + 3.52 \cos 4\varphi - 1.06 \cos 5\varphi \\ - 4.00 \cos 6\varphi + 0.32 \sin \varphi - 0.22 \sin 2\varphi + 1.08 \sin 3\varphi - 0.32 \sin 4\varphi + 0.76 \sin 5\varphi$$

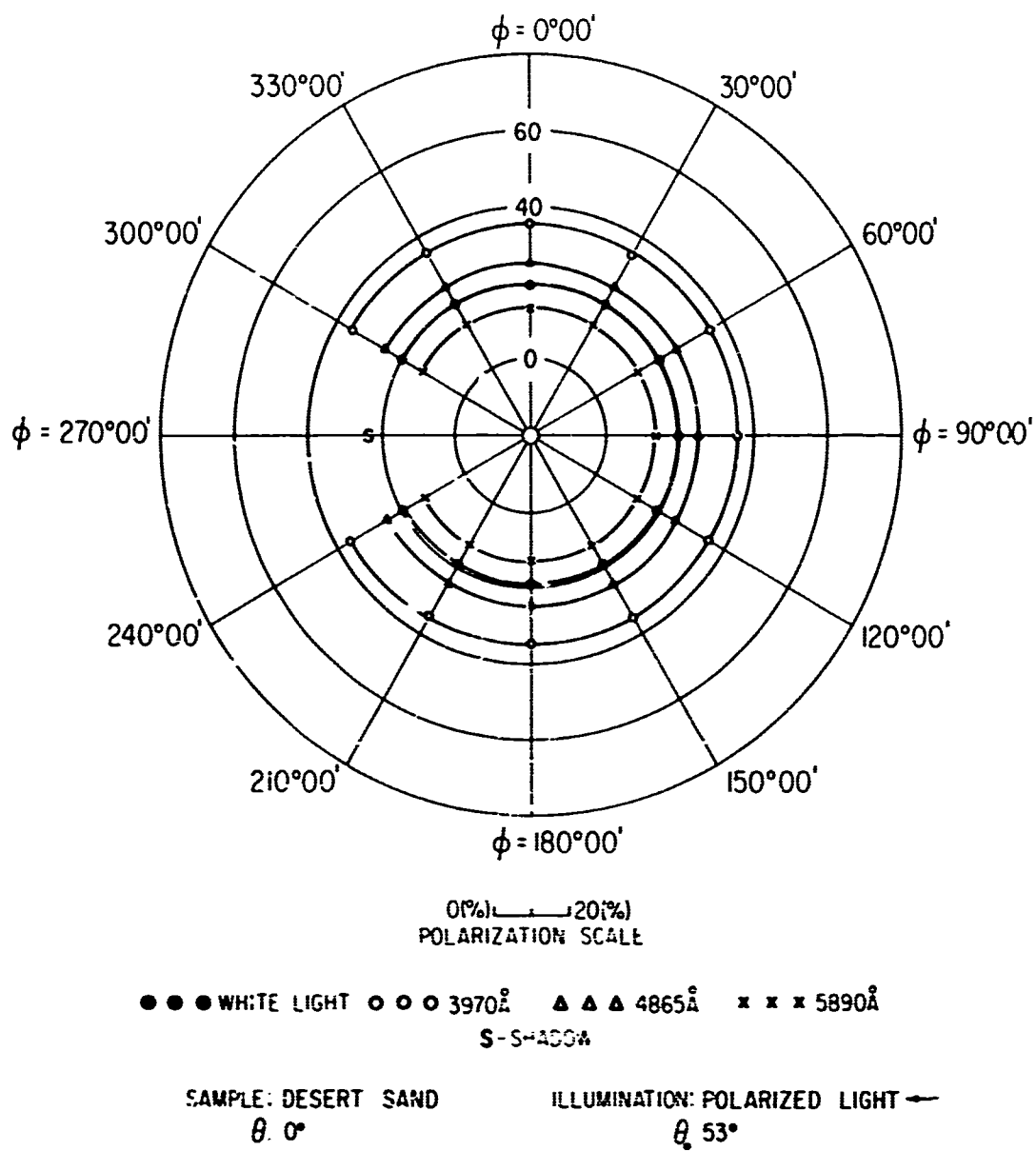


FIG 40. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

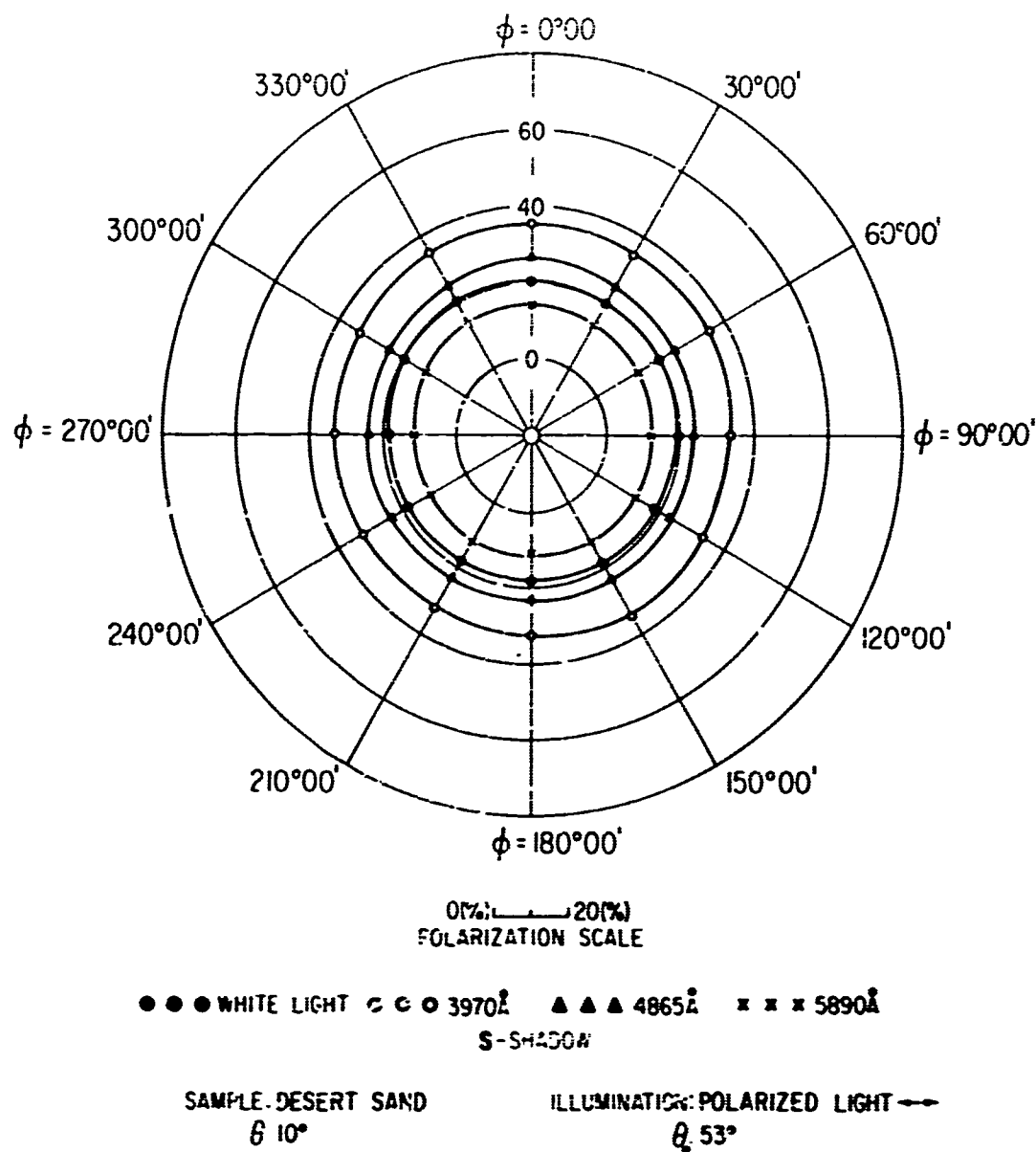


FIG 4I. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 19.08 + 1.20 \cos \phi + 0.41 \cos 2\phi - 0.01 \cos 3\phi + 0.14 \cos 4\phi - 0.04 \cos 5\phi \\
 & - 0.33 \cos 6\phi - 0.07 \sin \phi - 0.07 \sin 2\phi + 0.01 \sin 3\phi - 0.16 \sin 4\phi - 0.12 \sin 5\phi
 \end{aligned}$$

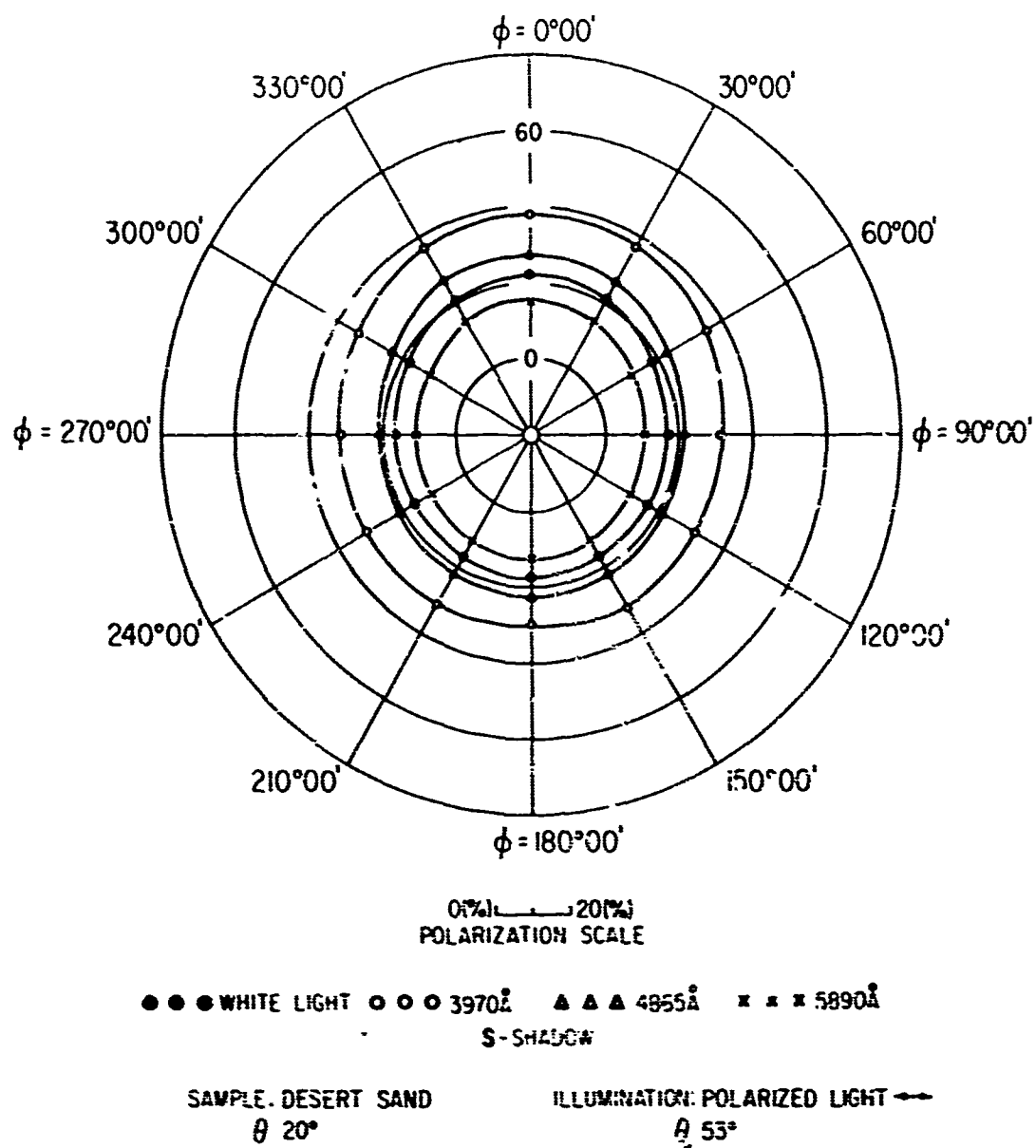


FIG 42. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 18.26 + 1.69 \cos \phi + 2.16 \cos 2\phi - 0.10 \cos 3\phi + 0.21 \cos 4\phi - 0.19 \cos 5\phi \\
 & + 0.13 \cos 6\phi + 0.06 \sin \phi + 0.07 \sin 2\phi + 0.03 \sin 3\phi + 0.01 \sin 4\phi + 0.33 \sin 5\phi
 \end{aligned}$$

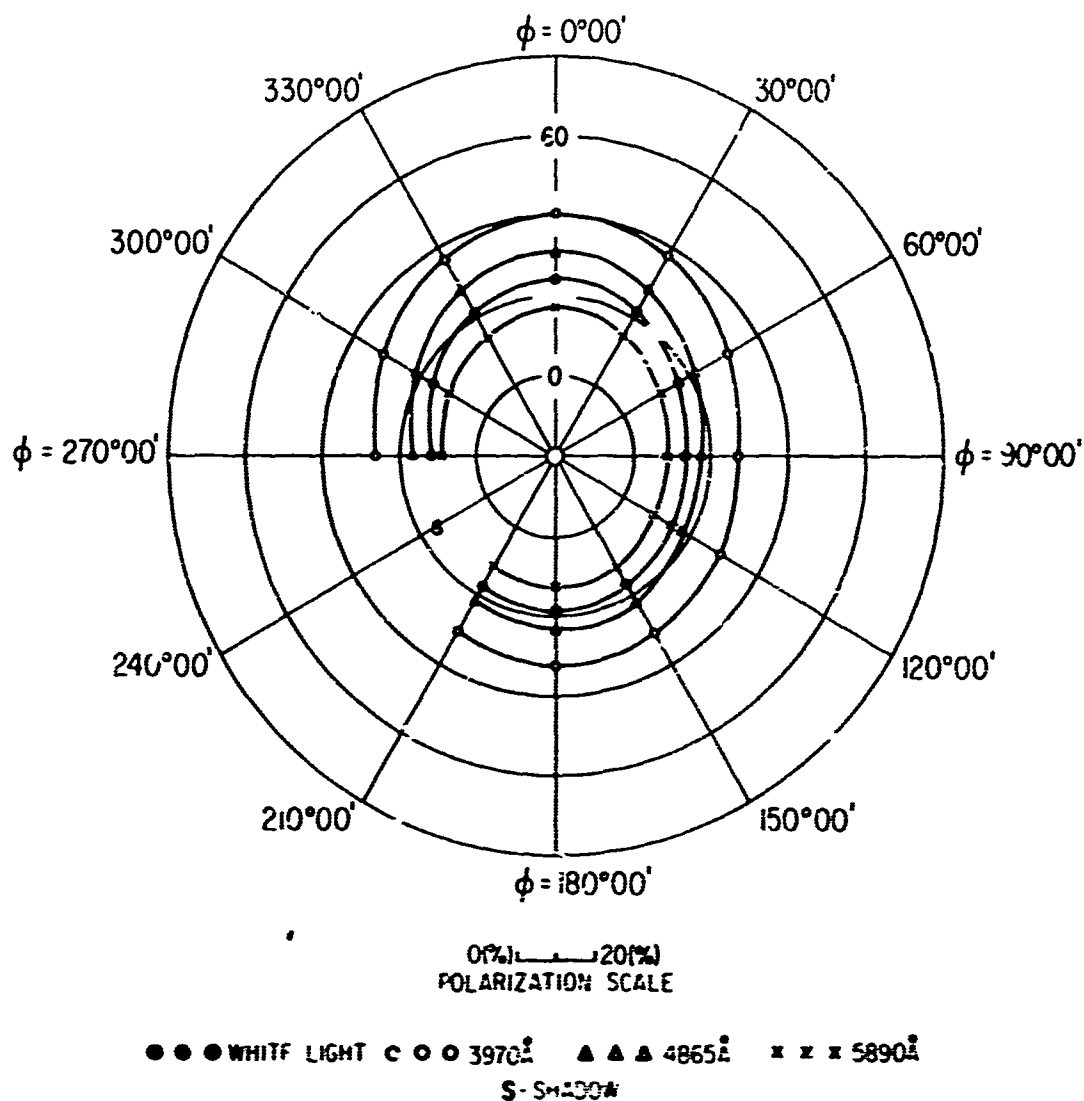


FIG 43. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 17.38 + 2.39 \cos \phi + 4.15 \cos 2\phi + 0.33 \cos 3\phi + 0.01 \cos 4\phi - 0.03 \cos 5\phi \\
 & + 0.30 \cos 6\phi - 0.01 \sin \phi + 0.09 \sin 2\phi - 0.13 \sin 3\phi + 0.09 \sin 4\phi - 0.01 \sin 5\phi
 \end{aligned}$$

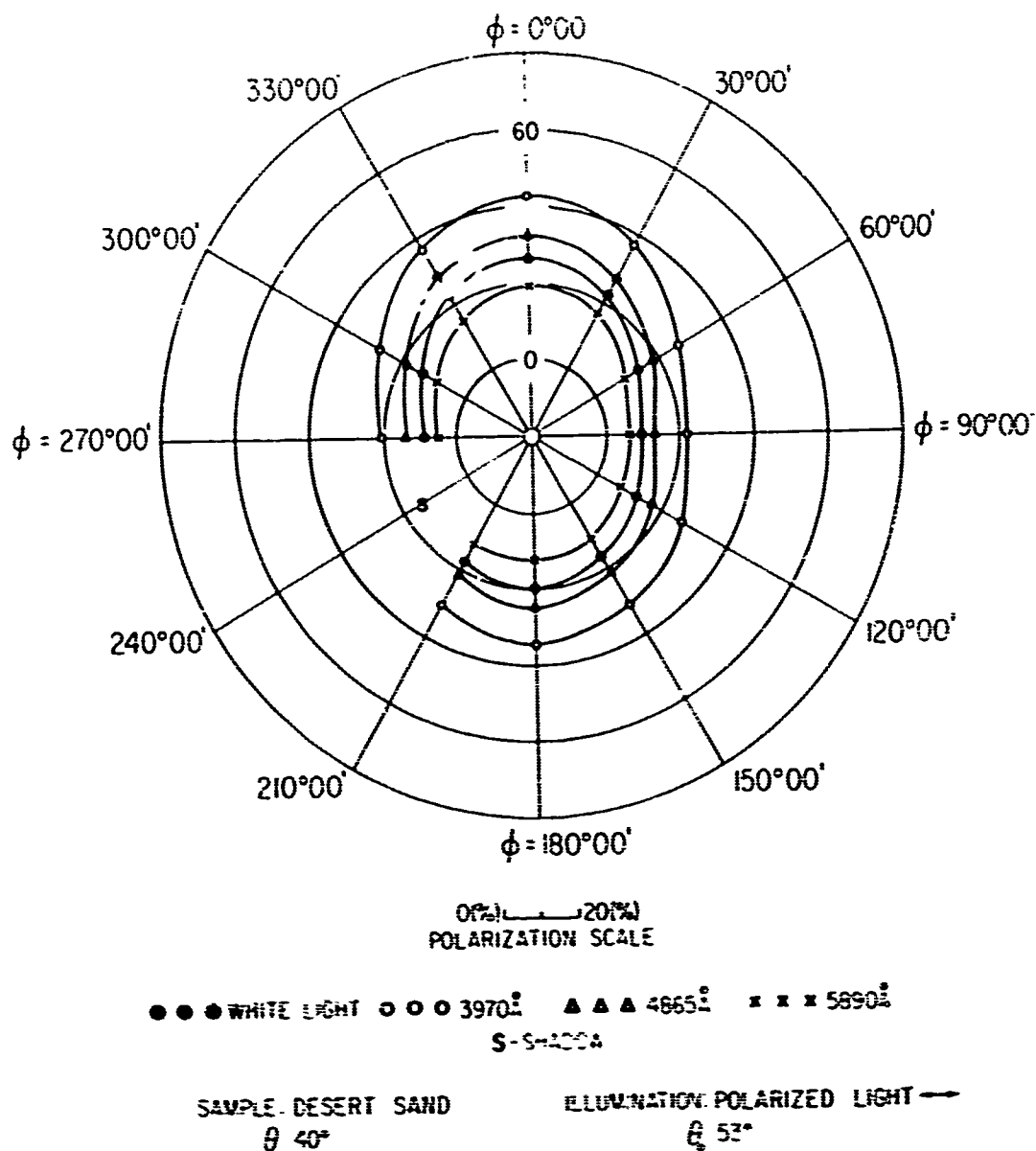


FIG 44. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 16.44 + 2.47 \cos \phi + 7.31 \cos 2\phi + 0.66 \cos 3\phi + 0.16 \cos 4\phi - 0.04 \cos 5\phi \\
 & - 0.01 \cos 6\phi - 0.06 \sin \phi - 0.04 \sin 2\phi - 0.51 \sin 3\phi + 0.45 \sin 4\phi - 0.06 \sin 5\phi
 \end{aligned}$$

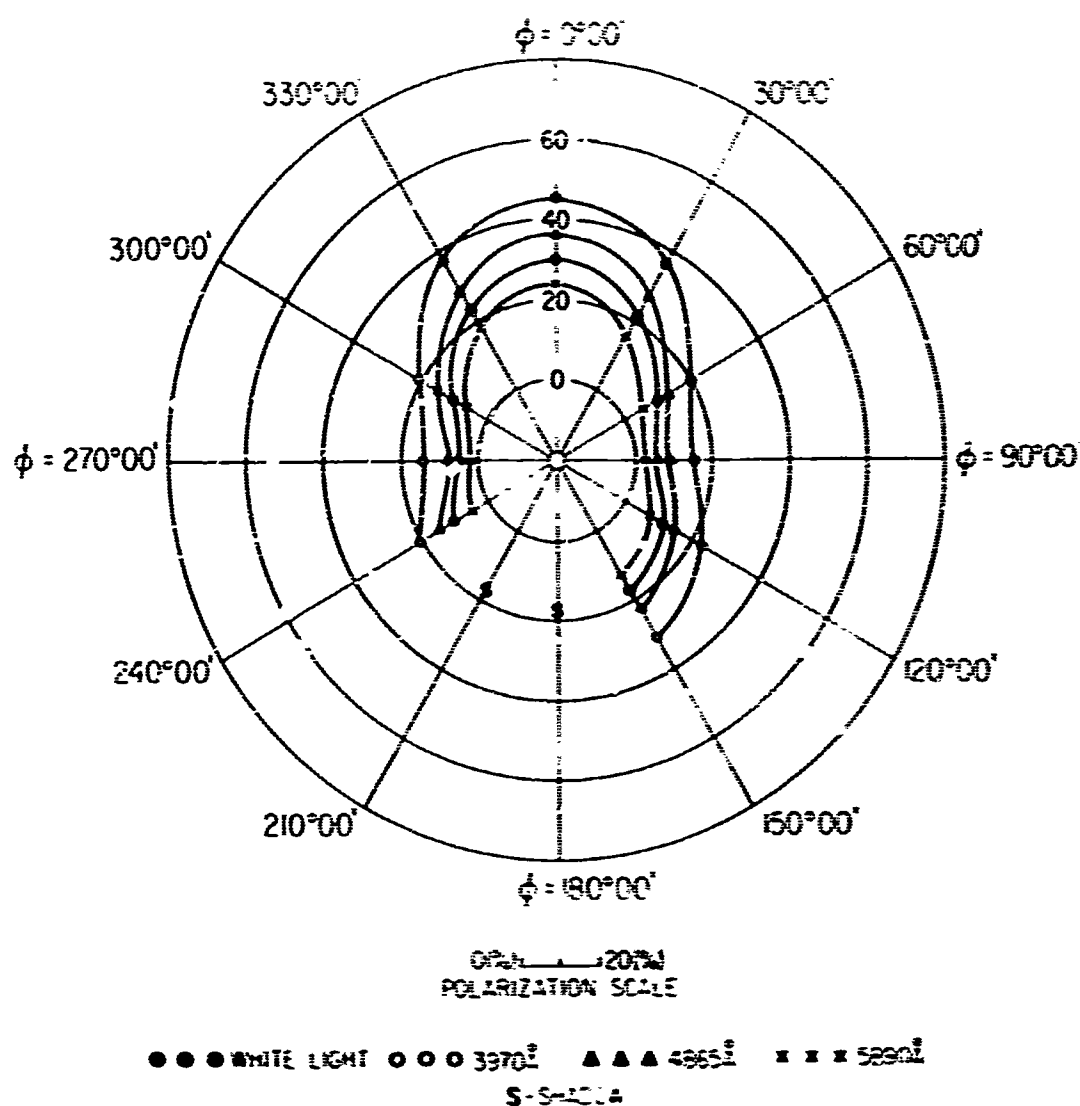


FIG 45. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 15.22 + 2.99 \cos \phi + 9.74 \cos 2\phi + 2.08 \cos 3\phi - 0.22 \cos 4\phi + 1.24 \cos 5\phi \\ - 0.08 \cos 6\phi - 0.10 \sin \phi - 0.48 \sin 2\phi - 0.43 \sin 3\phi - 0.05 \sin 4\phi - 0.01 \sin 5\phi$$

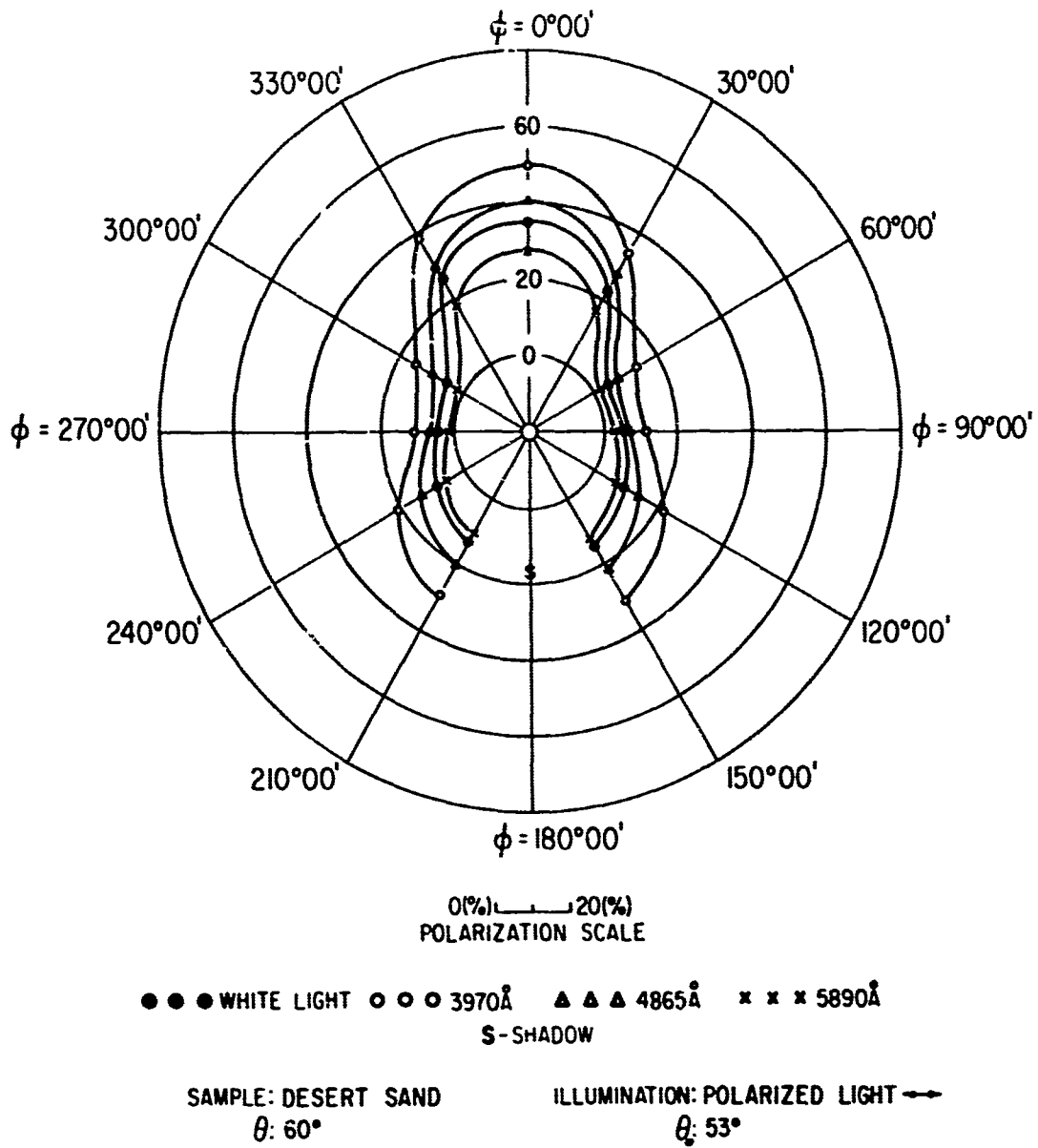


FIG 46. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 14.33 + 3.63 \cos \varphi + 11.97 \cos 2\varphi + 3.83 \cos 3\varphi + 1.01 \cos 4\varphi - 0.75 \cos 5\varphi \\
 & + 0.38 \cos 6\varphi - 0.23 \sin \varphi - 0.92 \sin 2\varphi - 0.38 \sin 3\varphi + 0.12 \sin 4\varphi - 0.20 \sin 5\varphi
 \end{aligned}$$

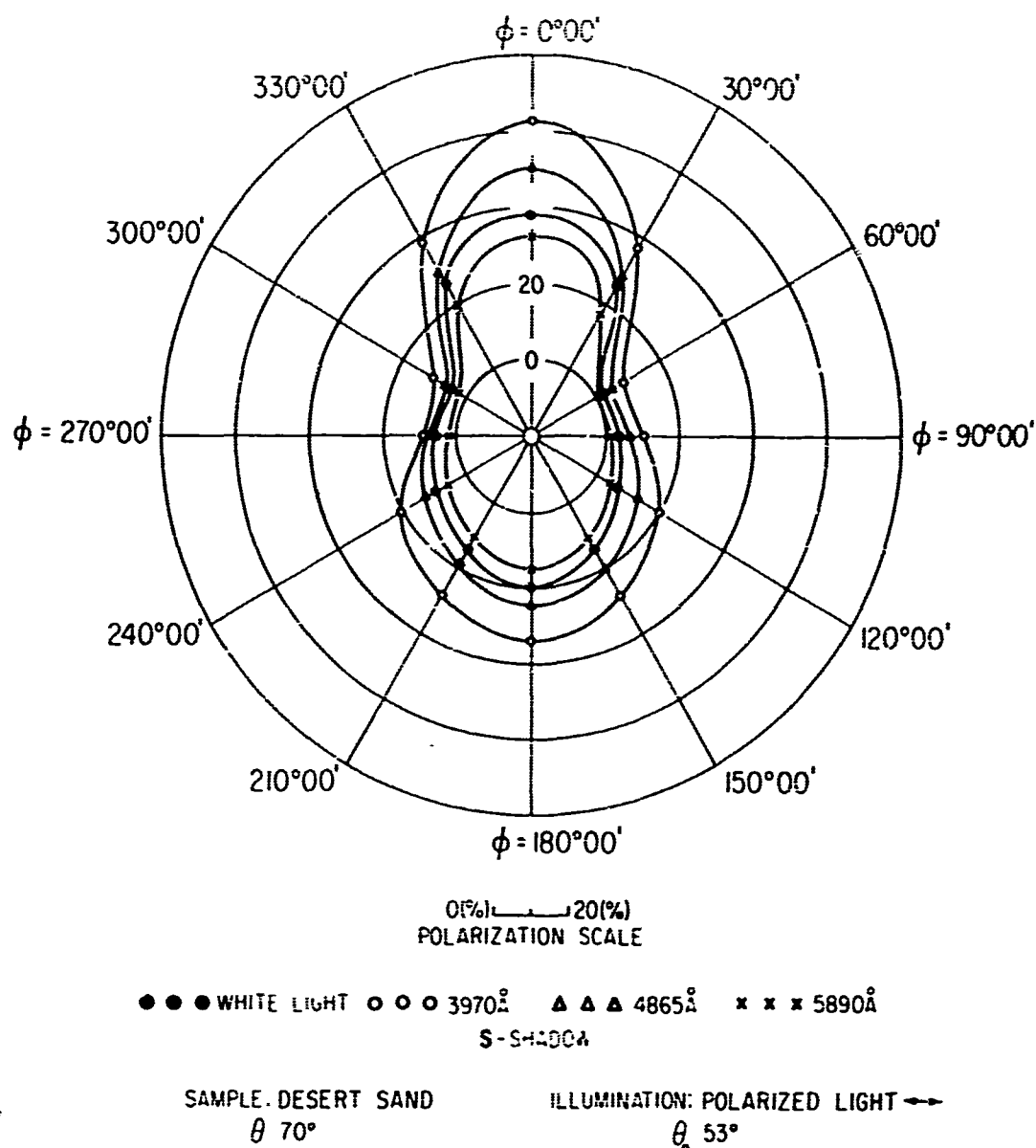


FIG 47. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 14.40 + 5.22 \cos \phi + 13.06 \cos 2\phi + 4.96 \cos 3\phi + 1.82 \cos 4\phi - 1.49 \cos 5\phi \\
 & - 0.80 \cos 6\phi - 0.23 \sin \phi - 0.48 \sin 2\phi - 0.16 \sin 3\phi + 0.27 \sin 4\phi + 0.41 \sin 5\phi
 \end{aligned}$$

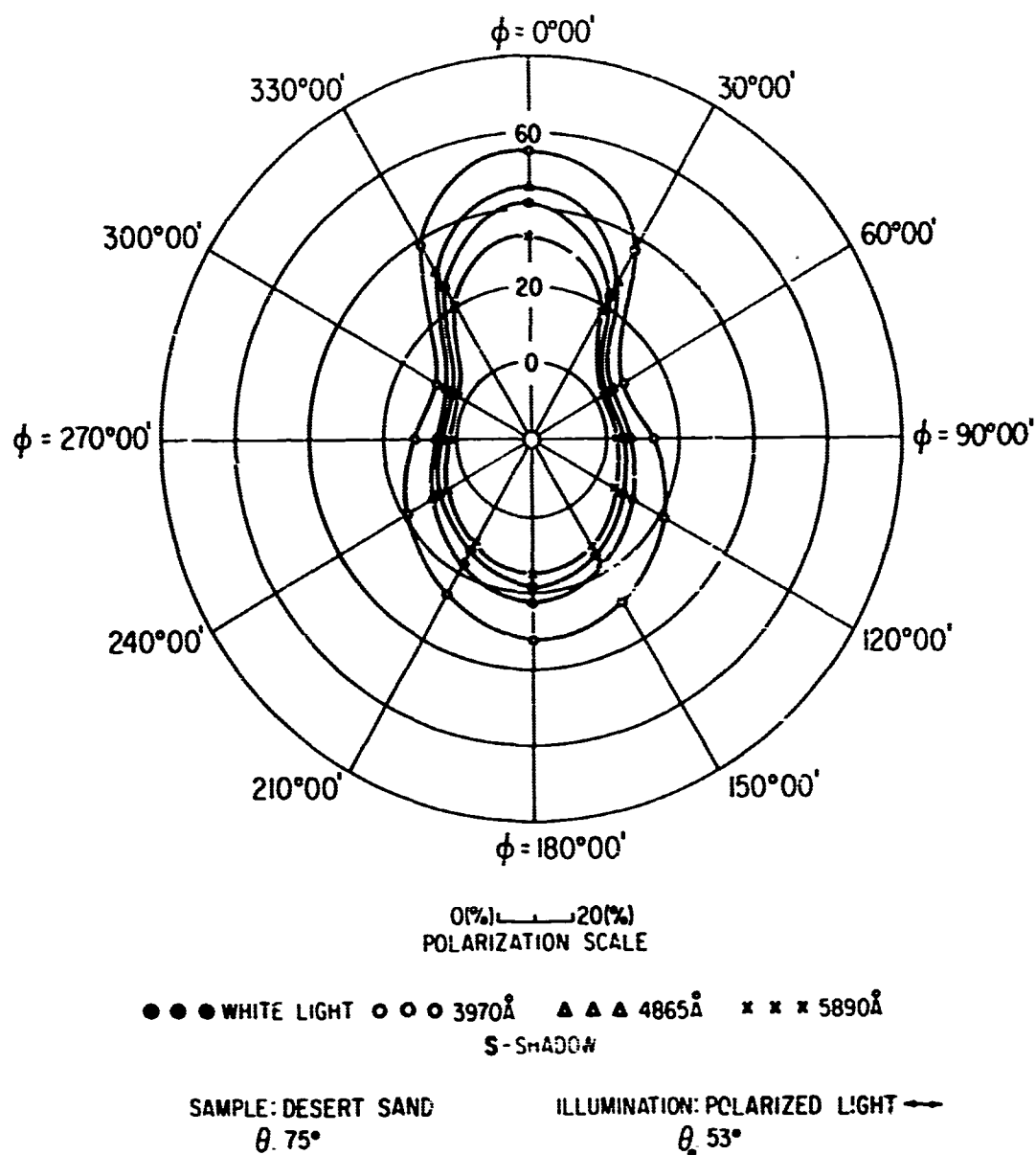
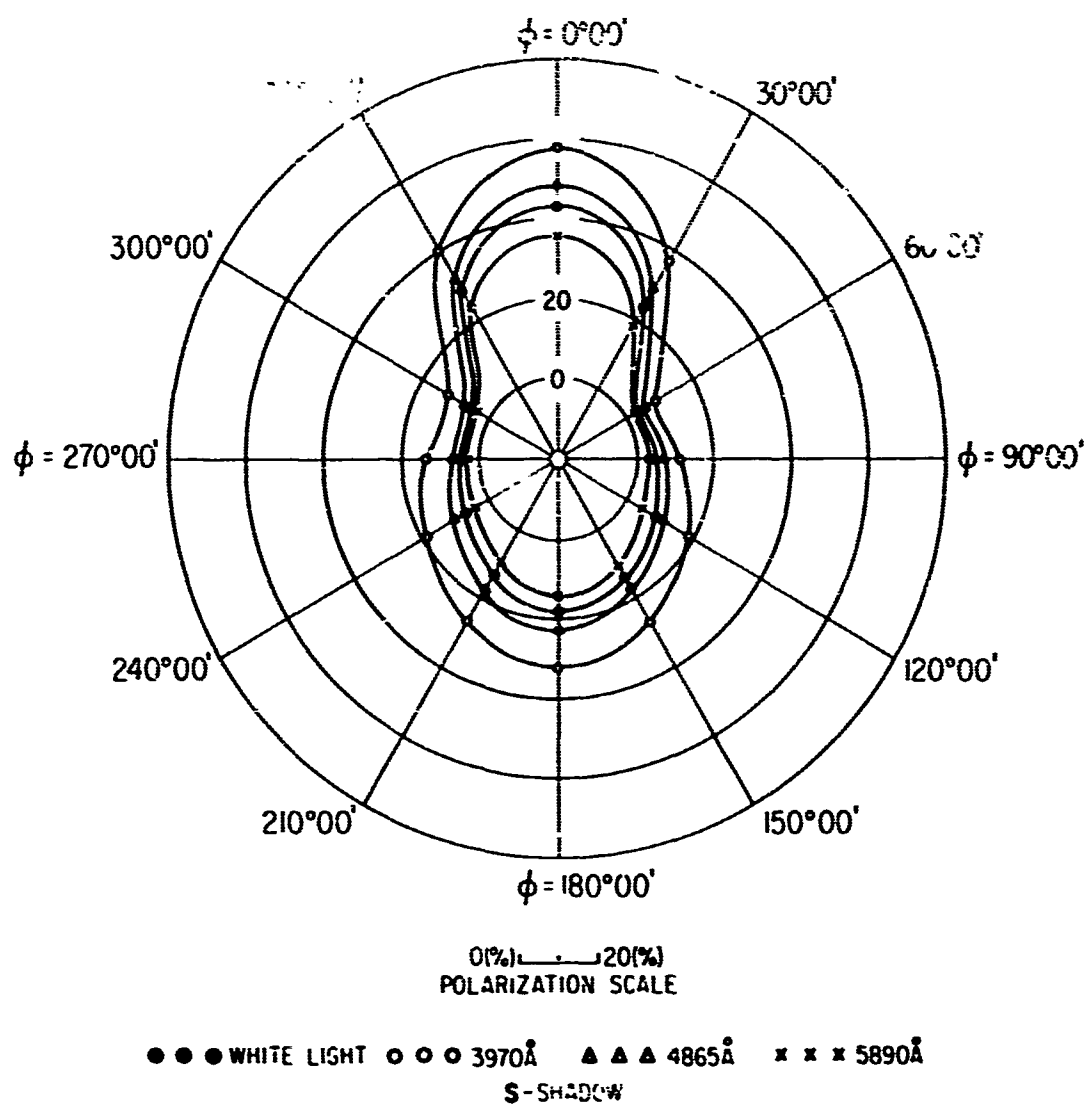


FIG 48. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 14.45 + 5.94 \cos \varphi + 12.66 \cos 2\varphi + 5.06 \cos 3\varphi + 3.08 \cos 4\varphi + 0.06 \cos 5\varphi + 0.03 \cos 6\varphi - 0.35 \sin \varphi - 1.12 \sin 2\varphi - 0.53 \sin 3\varphi - 0.53 \sin 4\varphi - 0.08 \sin 5\varphi$$



SAMPLE: DESERT SAND
 $\theta: 80^\circ$

ILLUMINATION: POLARIZED LIGHT \longleftrightarrow
 $\theta_i: 53^\circ$

FIG 49. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 14.64 + 7.08 \cos \varphi + 13.09 \cos 2\varphi + 5.12 \cos 3\varphi + 3.16 \cos 4\varphi - 0.54 \cos 5\varphi \\
 & - 0.38 \cos 6\varphi - 0.44 \sin \varphi - 1.34 \sin 2\varphi - 0.76 \sin 3\varphi - 0.62 \sin 4\varphi - 1.14 \sin 5\varphi
 \end{aligned}$$

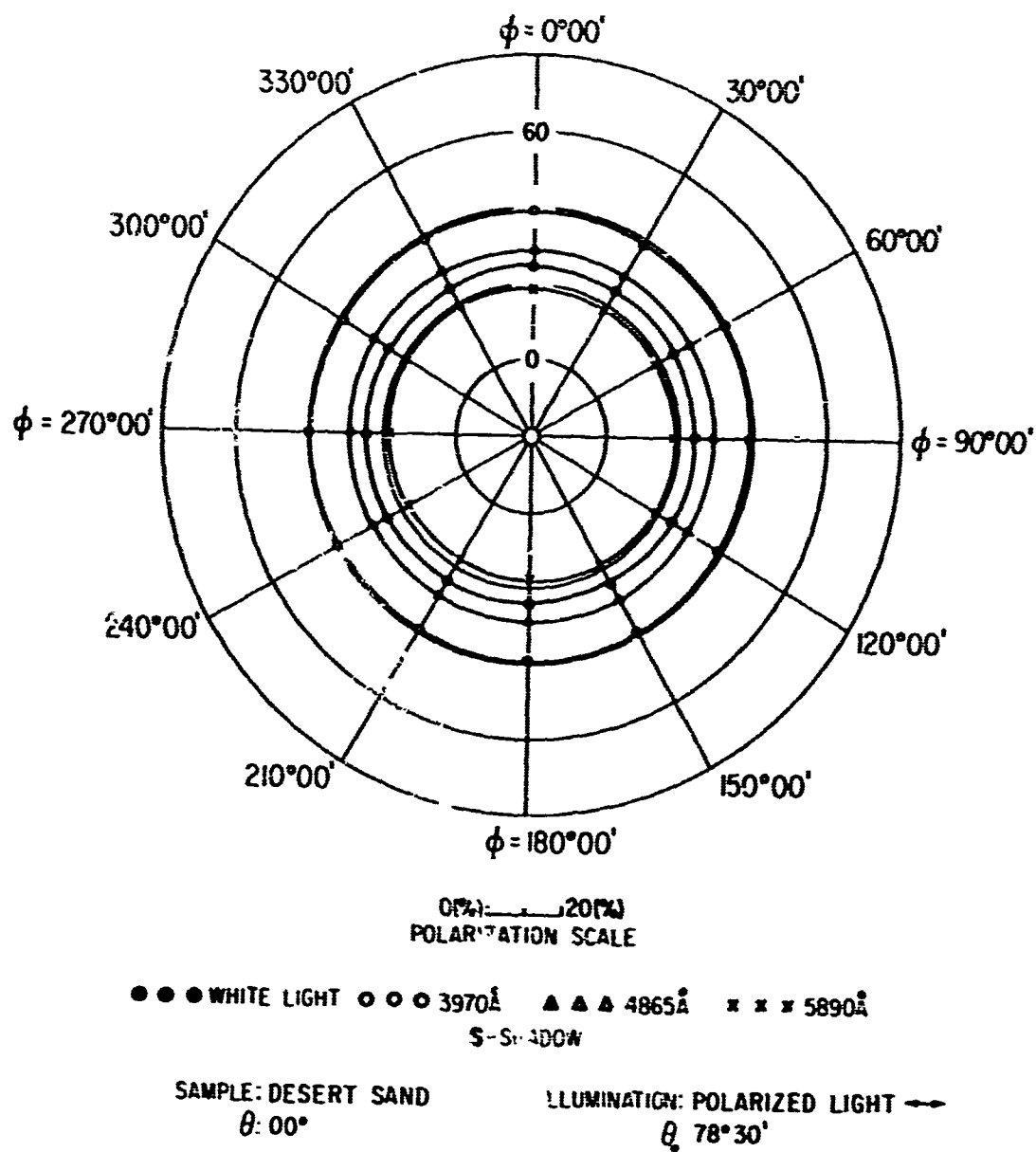


FIG 50. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

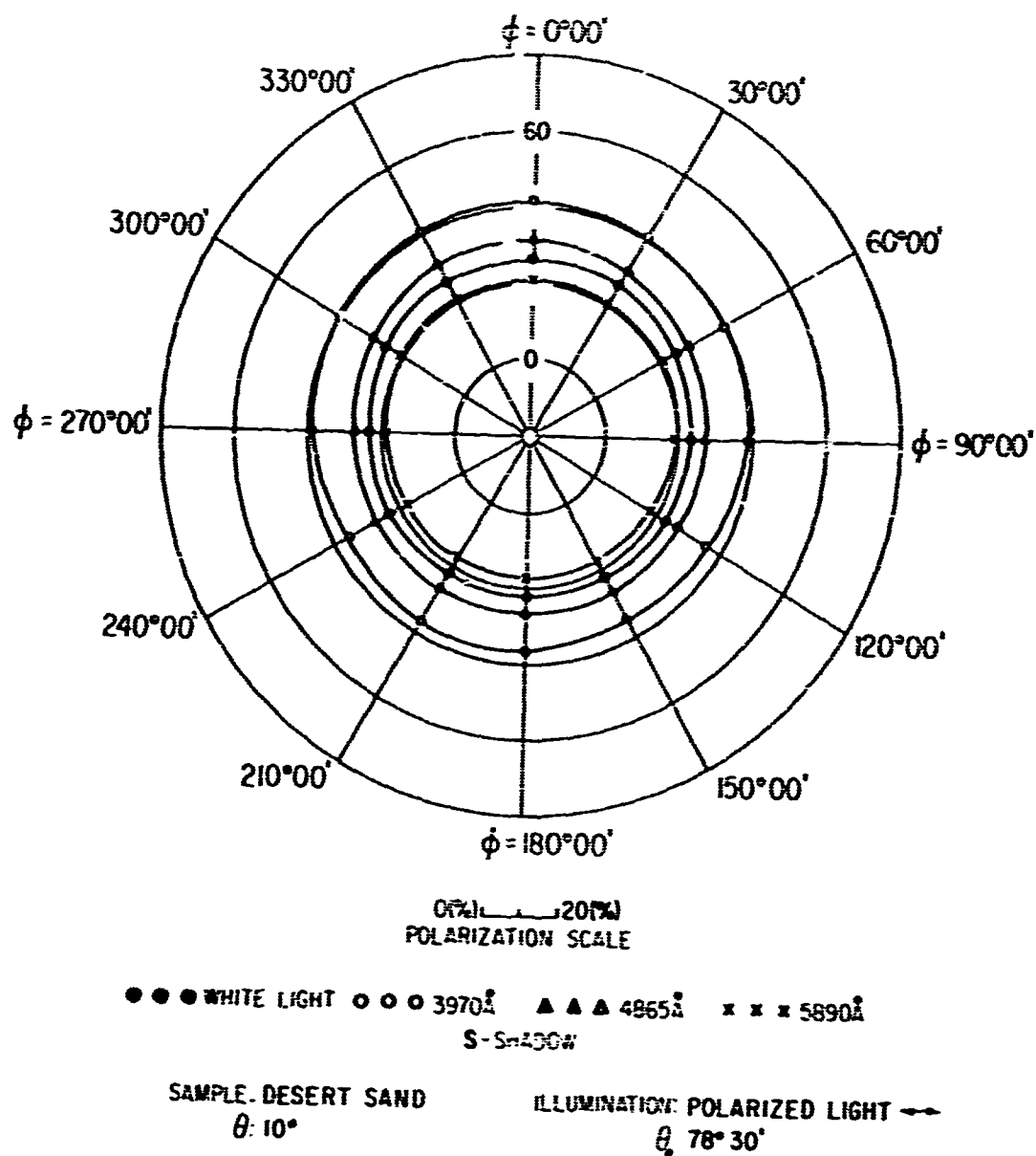


FIG 51. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 22.1 + 2.63 \cos \varphi + 0.38 \cos 2\varphi - 0.15 \cos 3\varphi + 0.17 \cos 4\varphi - 0.41 \cos 5\varphi \\
 & + 0.38 \cos 6\varphi + 0.23 \sin \varphi - 0.35 \sin 2\varphi + 0.467 \sin 3\varphi - 0.55 \sin 4\varphi + 0.31 \sin 5\varphi
 \end{aligned}$$

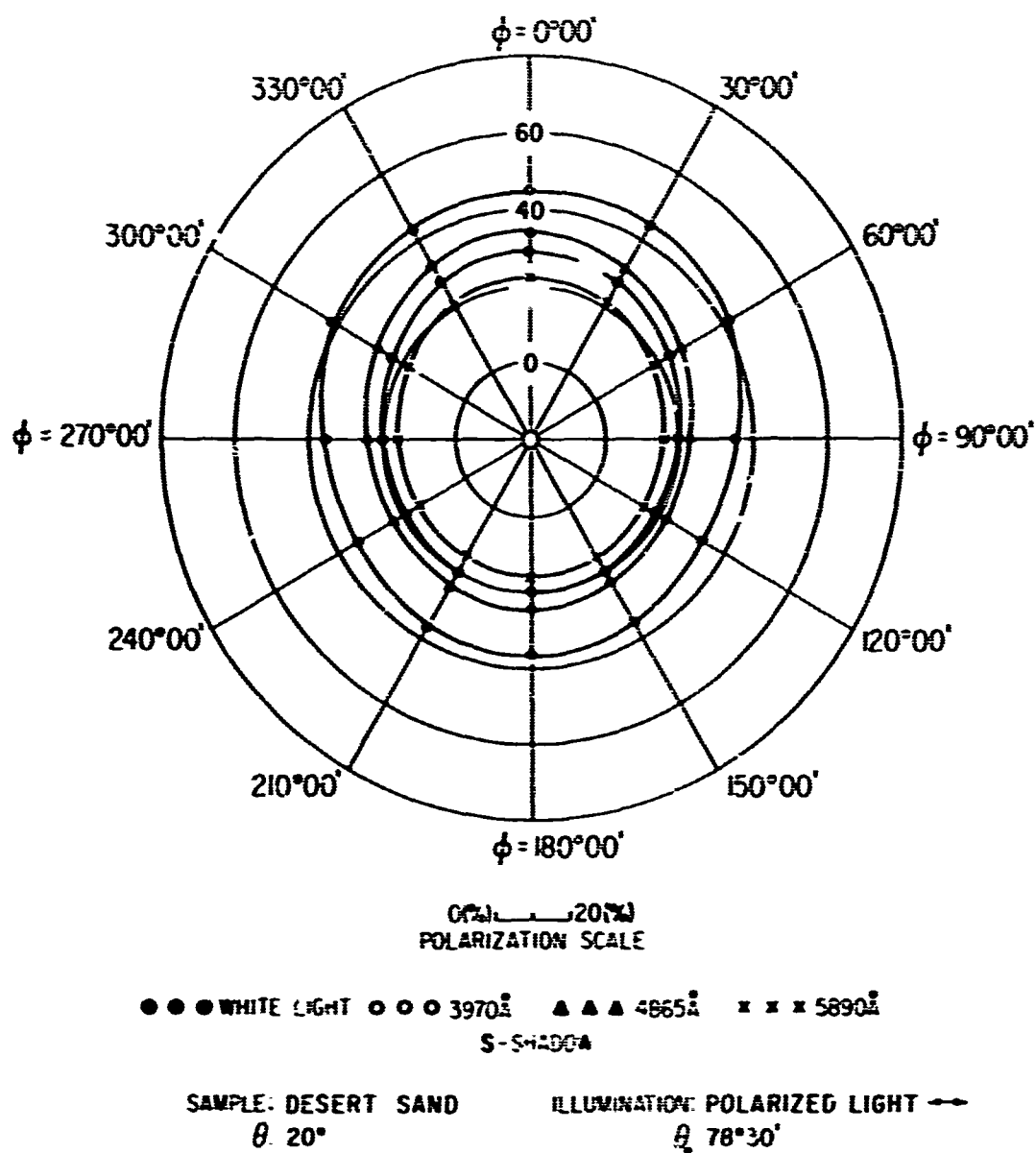


FIG 52. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 22.92 + 4.25 \cos \phi + 2.41 \cos 2\phi + 0.08 \cos 3\phi - 0.05 \cos 4\phi + 0.02 \cos 5\phi \\
 & - 0.28 \cos 6\phi - 0.03 \sin \phi + 0.06 \sin 2\phi - 0.07 \sin 3\phi + 0.10 \sin 4\phi - 0.07 \sin 5\phi
 \end{aligned}$$

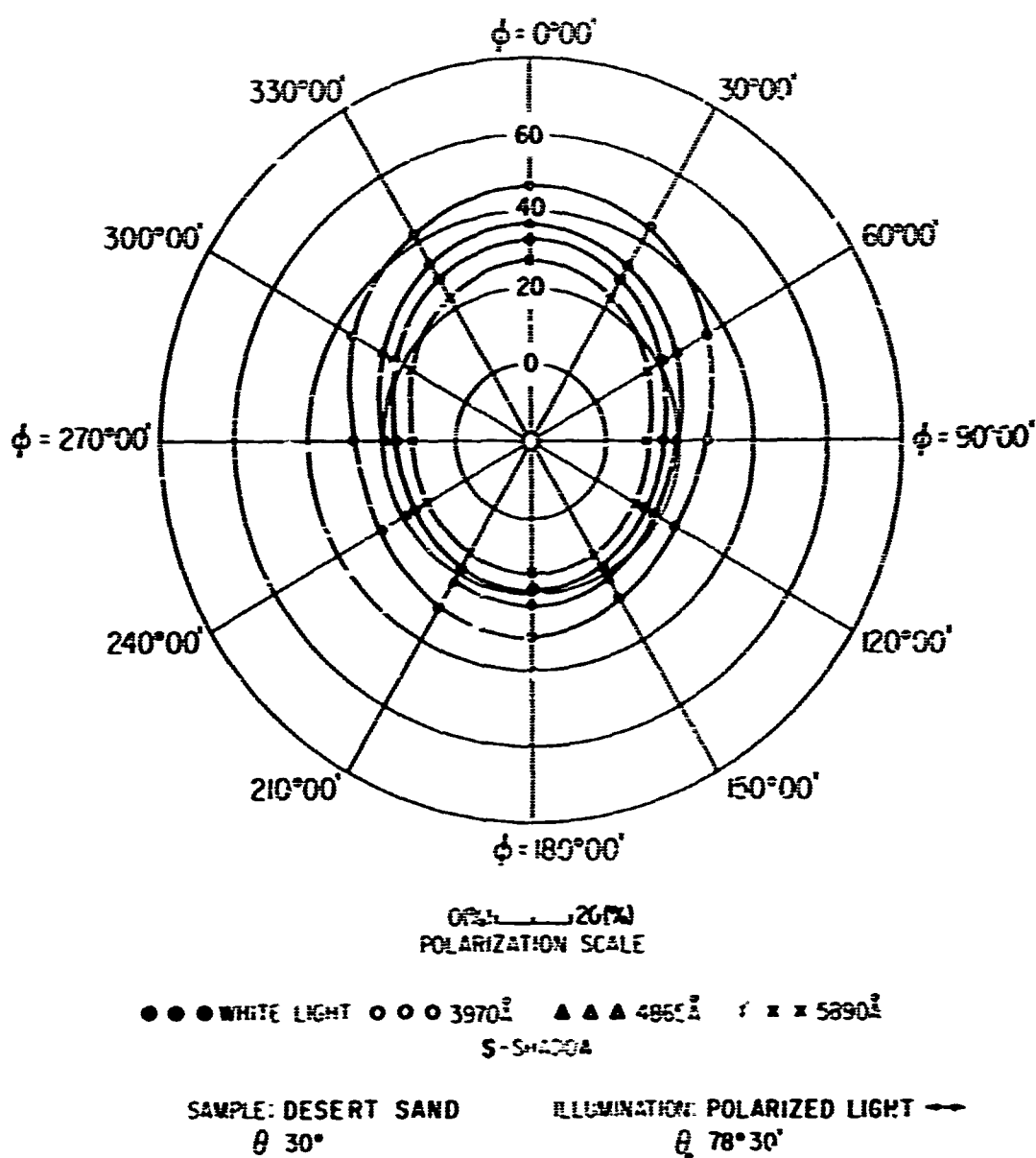


FIG 53. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 21.44 + 6.30 \cos \phi + 6.01 \cos 2\phi - 0.08 \cos 3\phi - 1.11 \cos 4\phi + 0.19 \cos 5\phi \\
 & + 0.15 \cos 6\phi - 0.01 \sin \phi + 0.03 \sin 2\phi - 0.13 \sin 3\phi + 0.03 \sin 4\phi + 0.02 \sin 5\phi
 \end{aligned}$$

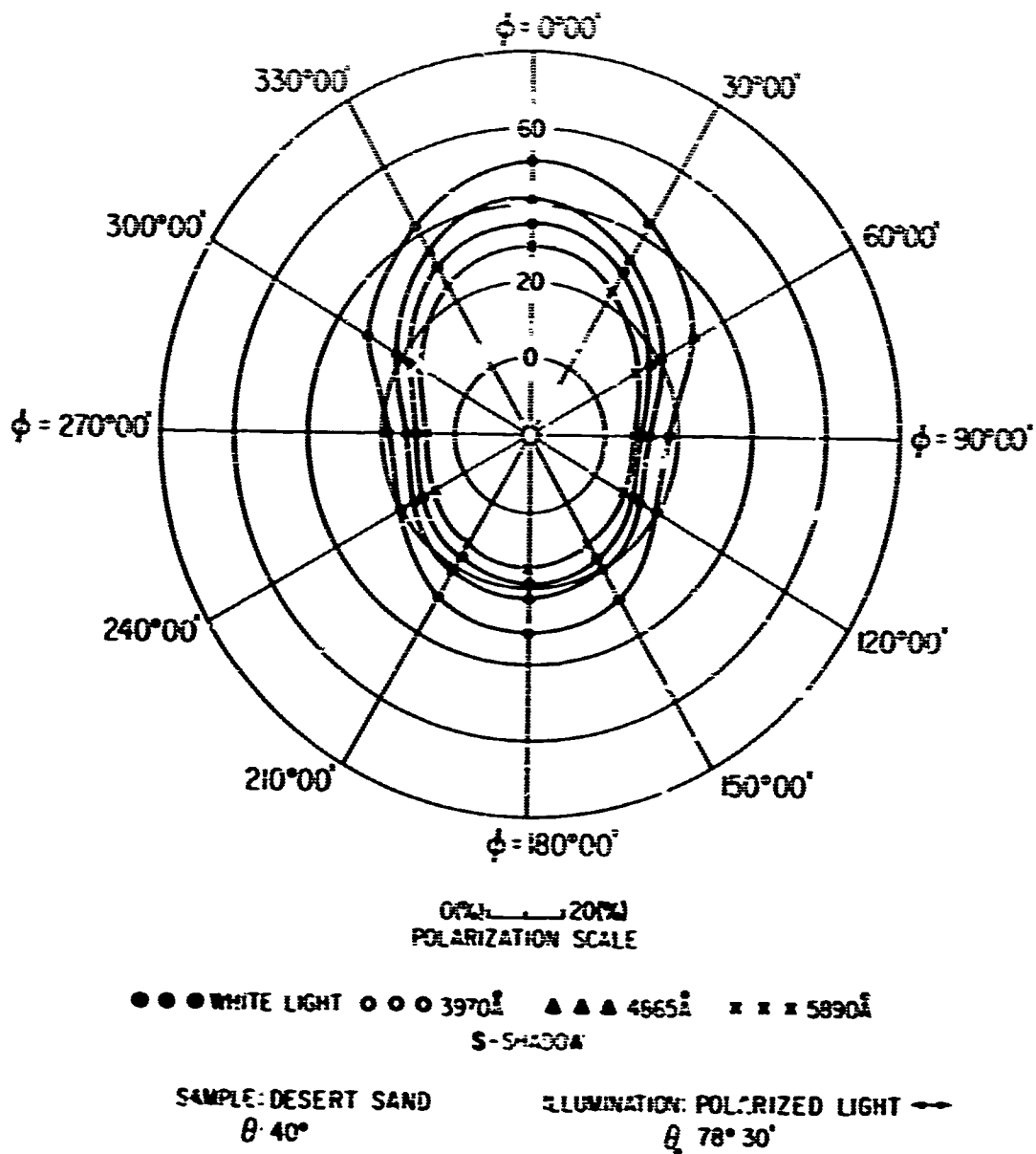


FIG 54. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 19.37 + 7.58 \cos \phi + 7.85 \cos 2\phi + 1.05 \cos 3\phi - 0.09 \cos 4\phi - 0.08 \cos 5\phi \\
 & + 1.43 \cos 6\phi - 0.06 \sin \phi + 0.01 \sin 2\phi - 0.12 \sin 3\phi + 0.01 \sin 4\phi + 0.06 \sin 5\phi
 \end{aligned}$$

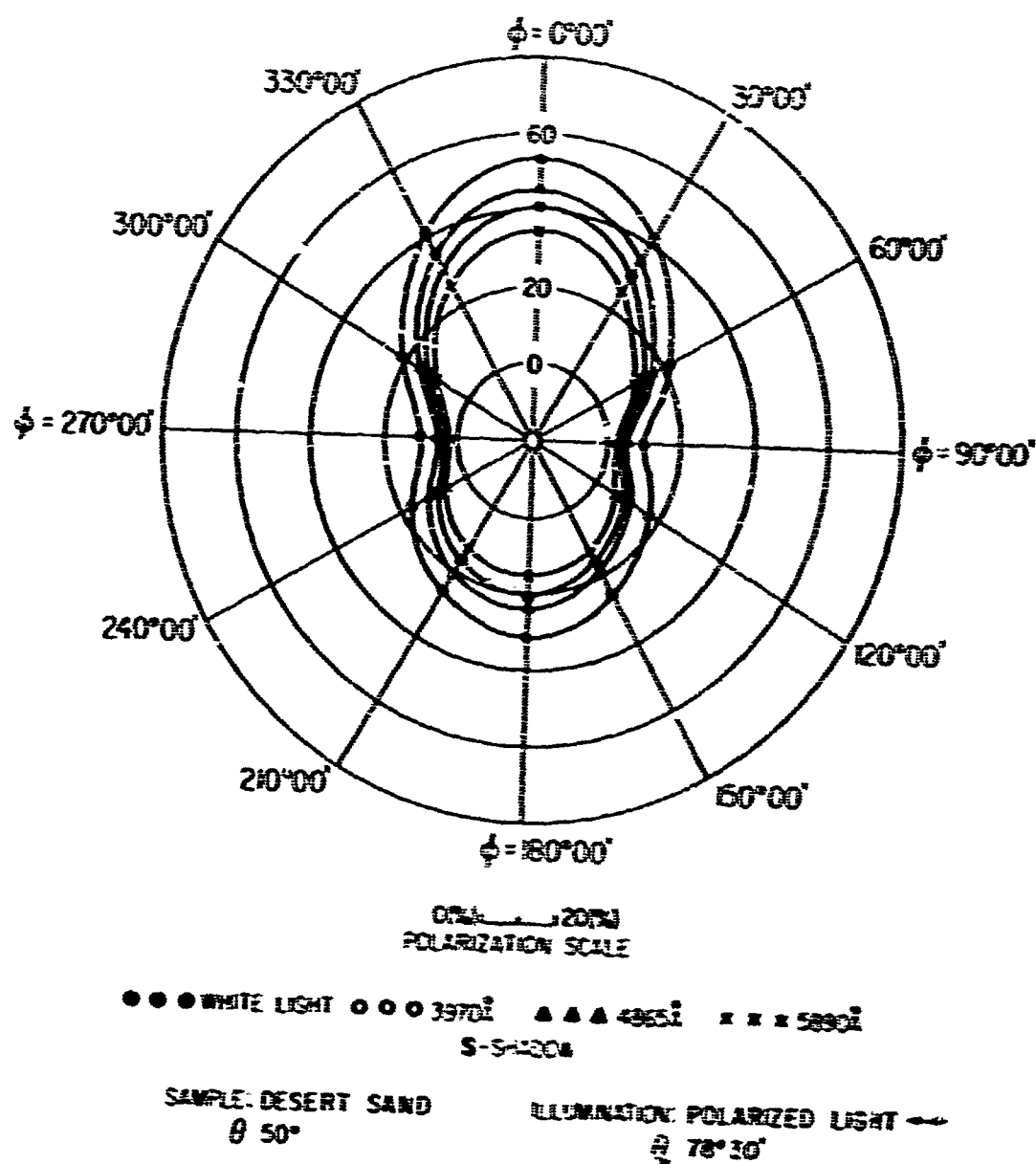


FIG 55. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 17.82 + 7.93 \cos \phi + 12.82 \cos 2\phi + 1.93 \cos 3\phi - 0.42 \cos 4\phi + 0.00 \cos 5\phi \\ - 0.39 \cos 6\phi + 0.11 \sin \phi + 0.20 \sin 2\phi - 0.23 \sin 3\phi + 0.20 \sin 4\phi - 0.13 \sin 5\phi$$

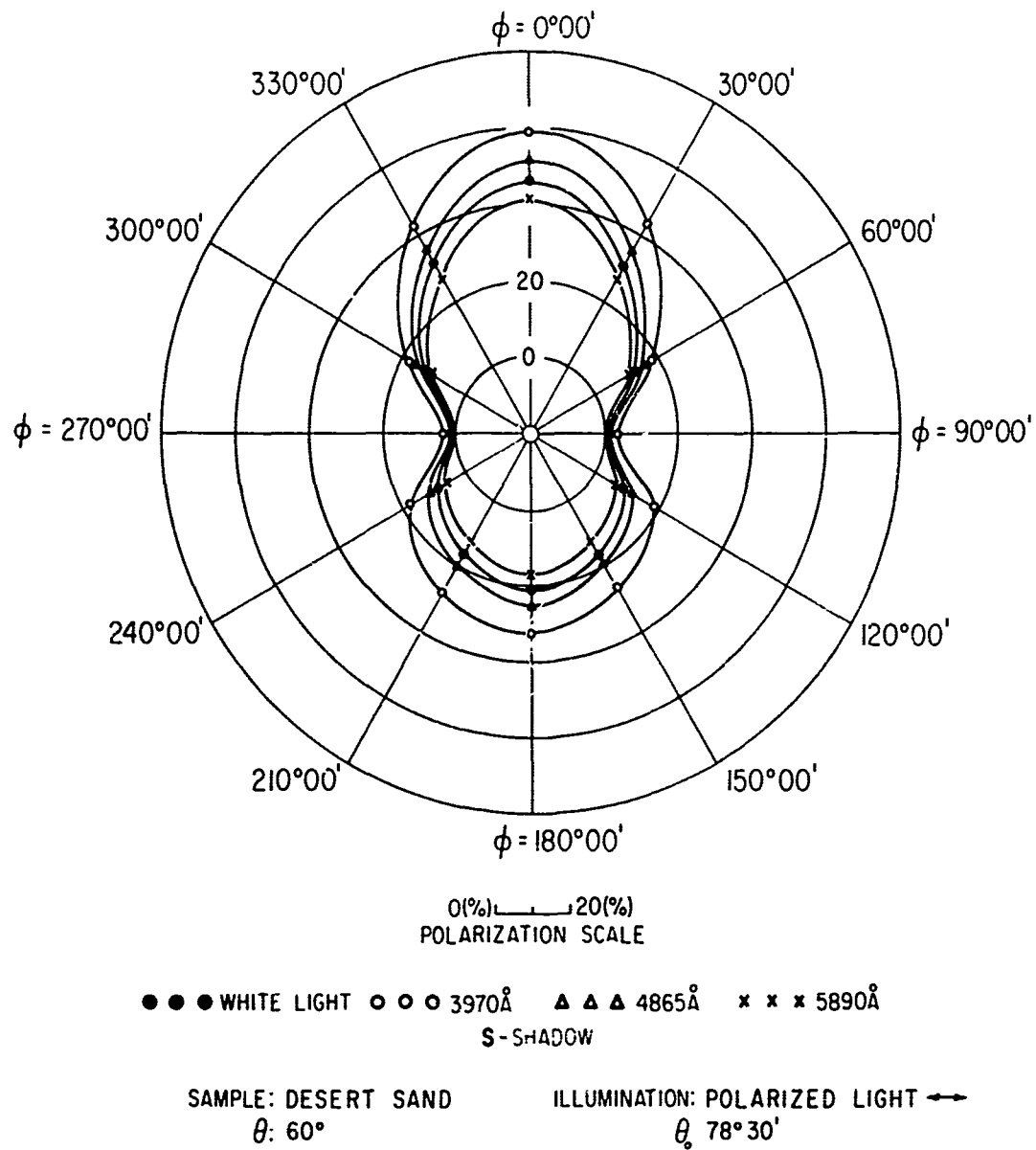


FIG 56. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 17.56 + 8.48 \cos \varphi + 15.39 \cos 2\varphi + 3.43 \cos 3\varphi + 0.32 \cos 4\varphi + 0.72 \cos 5\varphi \\
 & + 2.62 \cos 6\varphi + 0.12 \sin \varphi + 0.48 \sin 2\varphi + 0.25 \sin 3\varphi + 0.47 \sin 4\varphi + 0.12 \sin 5\varphi
 \end{aligned}$$

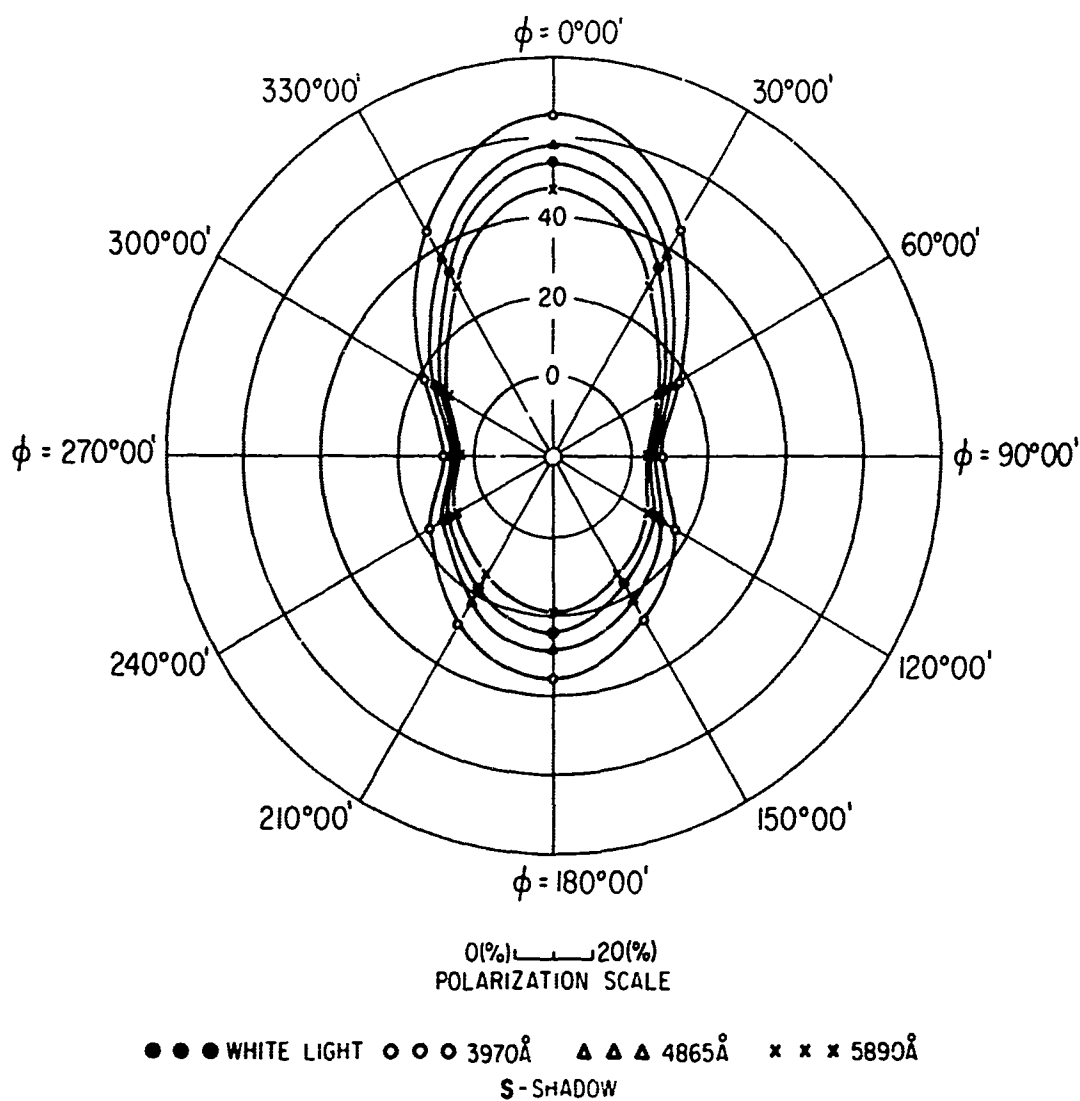


FIG 57. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 19.95 + 9.99 \cos \varphi + 16.44 \cos 2\varphi + 3.88 \cos 3\varphi + 2.32 \cos 4\varphi + 0.78 \cos 5\varphi \\
 & + 0.20 \cos 6\varphi + 0.02 \sin \varphi + 0.28 \sin 2\varphi + 0.05 \sin 3\varphi + 0.28 \sin 4\varphi + 0.02 \sin 5\varphi
 \end{aligned}$$

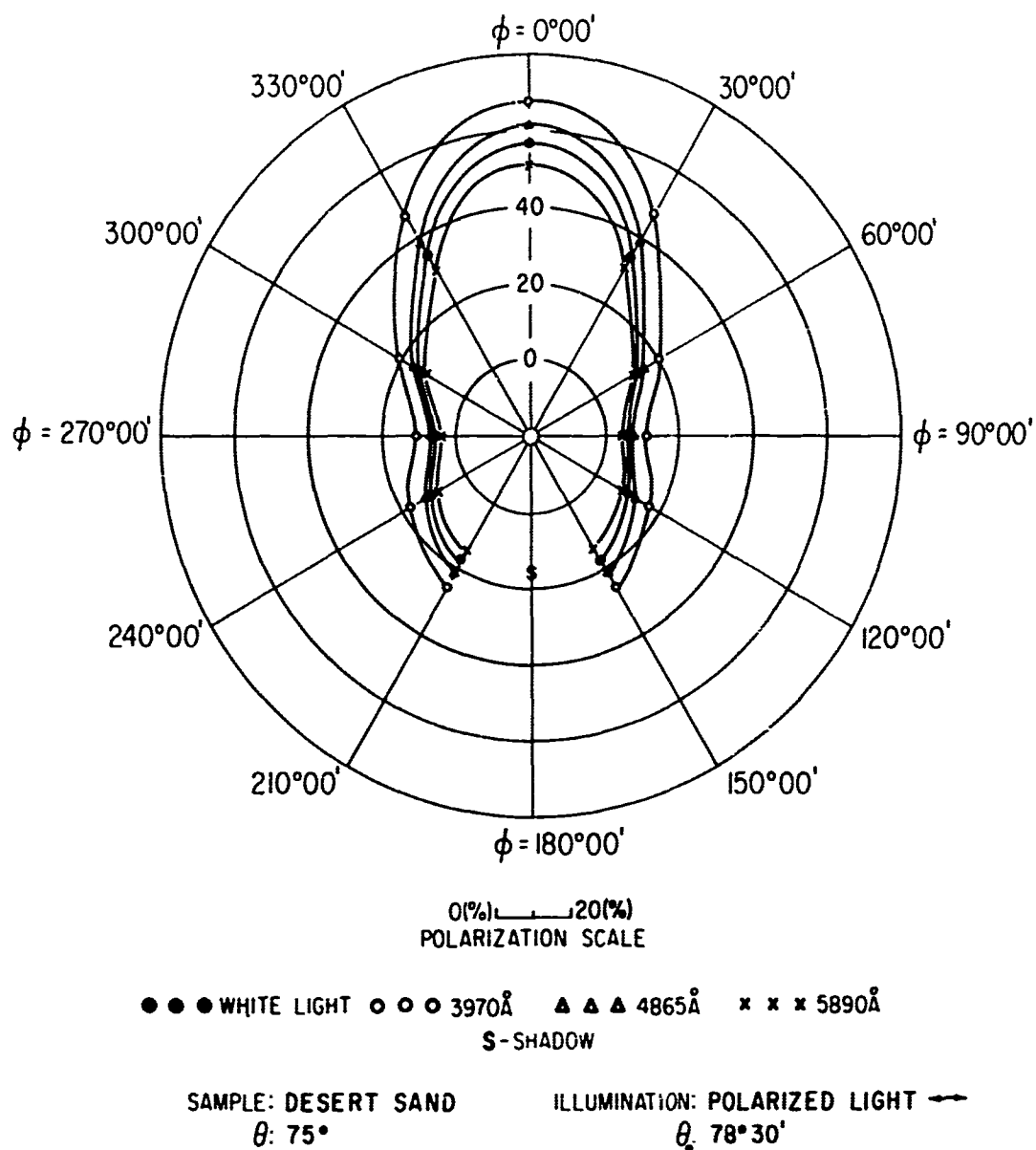


FIG 58. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 20.53 + 11.46 \cos \phi + 15.88 \cos 2\phi + 5.35 \cos 3\phi + 2.26 \cos 4\phi + 1.61 \cos 5\phi \\ + 1.62 \cos 6\phi + 0.09 \sin \phi + 0.16 \sin 2\phi + 0.18 \sin 3\phi + 0.16 \sin 4\phi + 0.09 \sin 5\phi$$

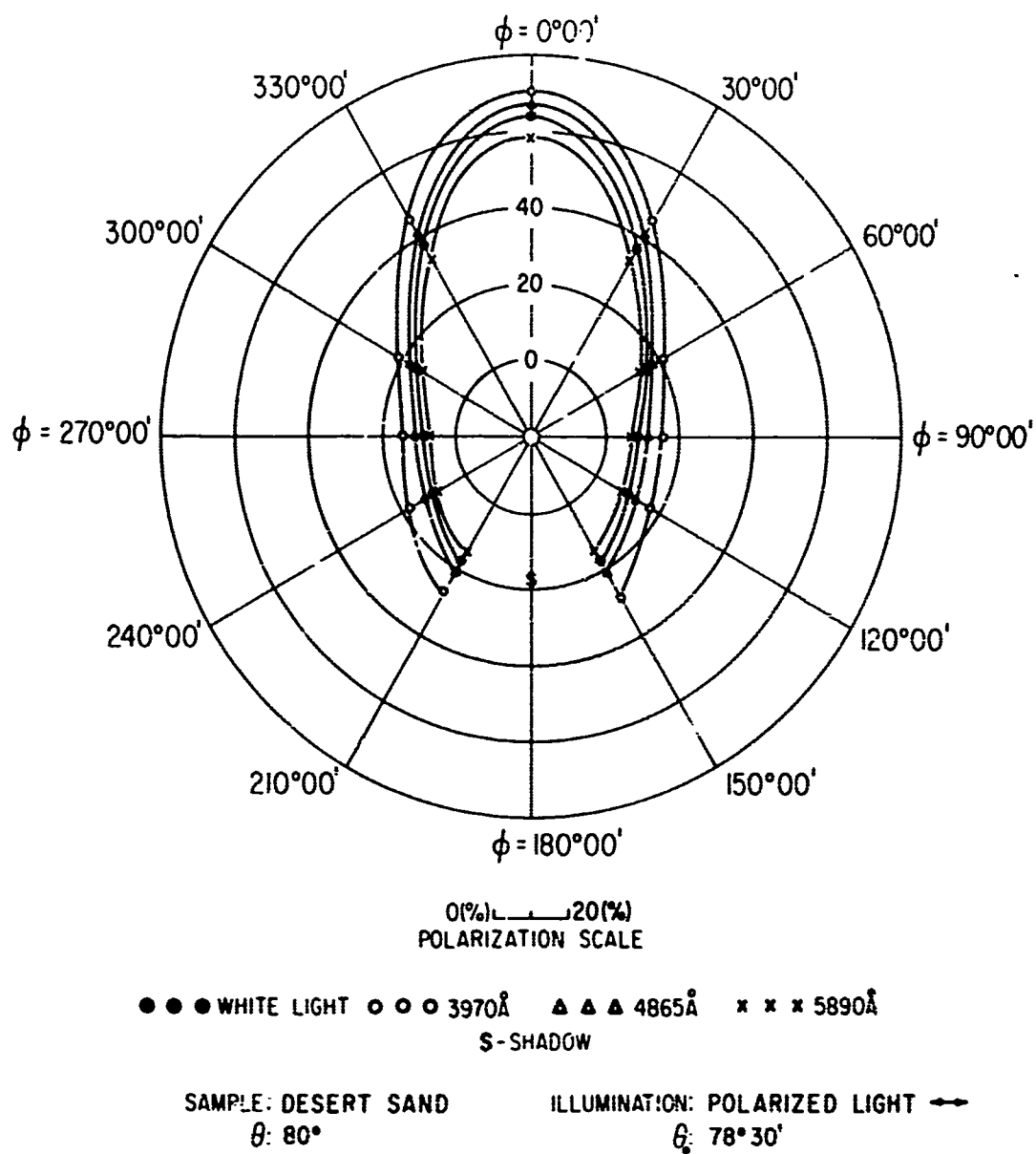
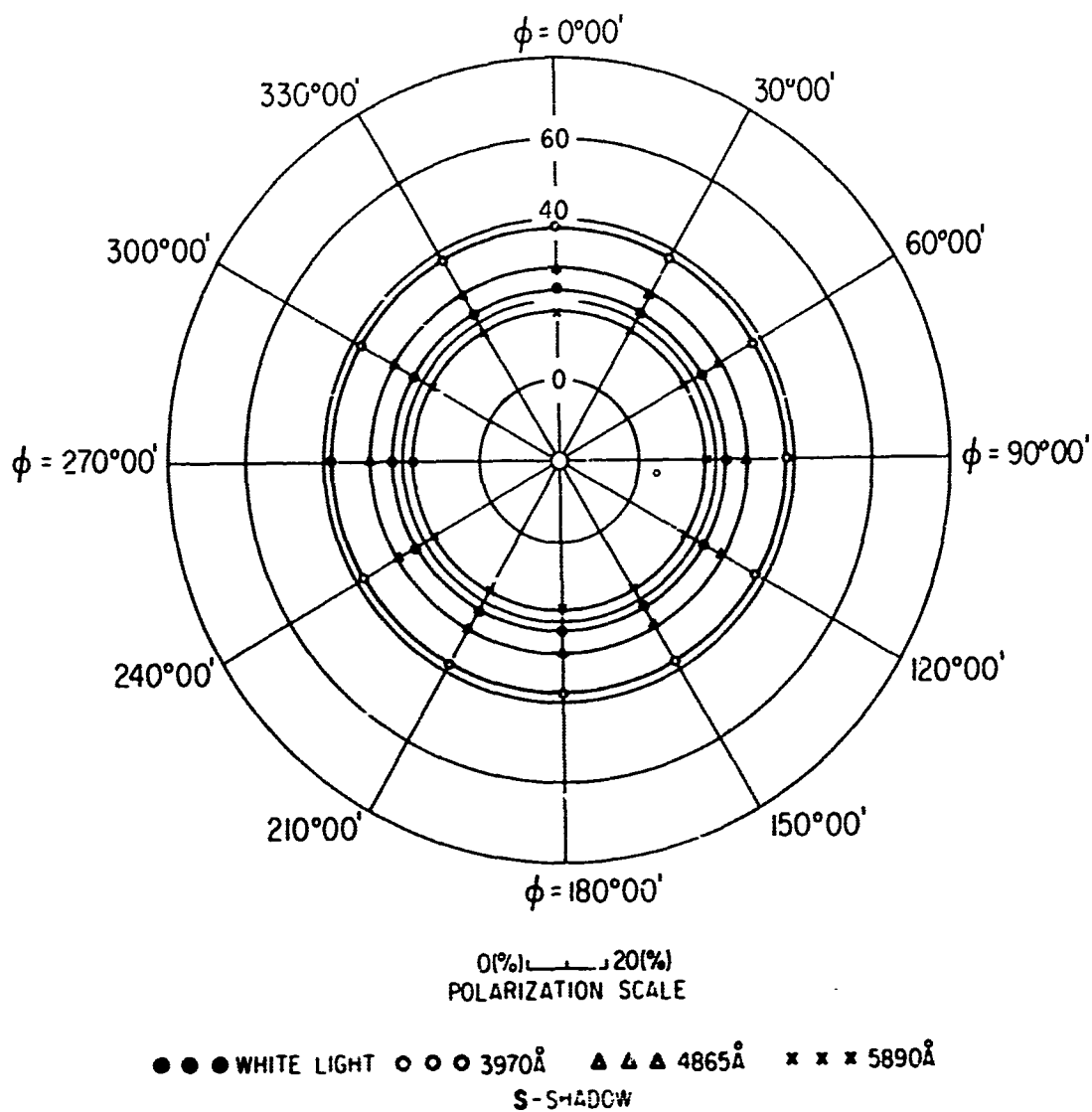


FIG 59. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 22.2 + 13.20 \cos \varphi + 17.58 \cos 2\varphi + 4.58 \cos 3\varphi + 3.42 \cos 4\varphi + 1.86 \cos 5\varphi \\
 & + 2.90 \cos 6\varphi + 0.16 \sin \varphi + 0.28 \sin 2\varphi + 0.32 \sin 3\varphi + 0.27 \sin 4\varphi + 0.16 \sin 6\varphi
 \end{aligned}$$

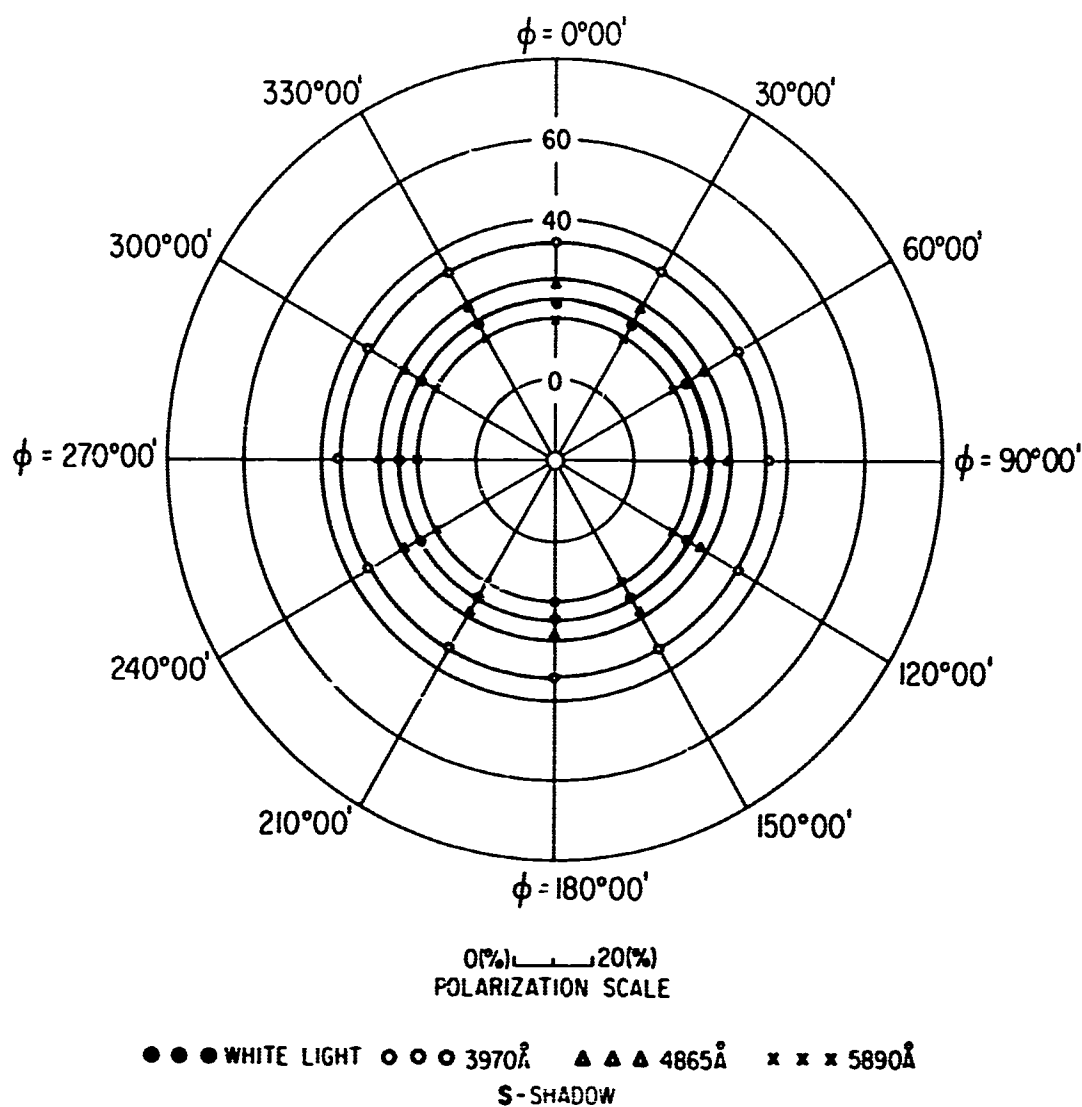


SAMPLE: DESERT SAND
 $\theta: 10^\circ$

ILLUMINATION: POLARIZED LIGHT
 $\theta: 0^\circ$

FIG 60. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 22.38 - 0.11 \cos \varphi + 0.36 \cos 2\varphi - 0.08 \cos 3\varphi + 0.42 \cos 4\varphi - 0.11 \cos 5\varphi \\
 & + 0.02 \cos 6\varphi - 0.12 \sin \varphi + 0.13 \sin 2\varphi - 0.10 \sin 3\varphi - 0.07 \sin 4\varphi - 0.08 \sin 5\varphi
 \end{aligned}$$

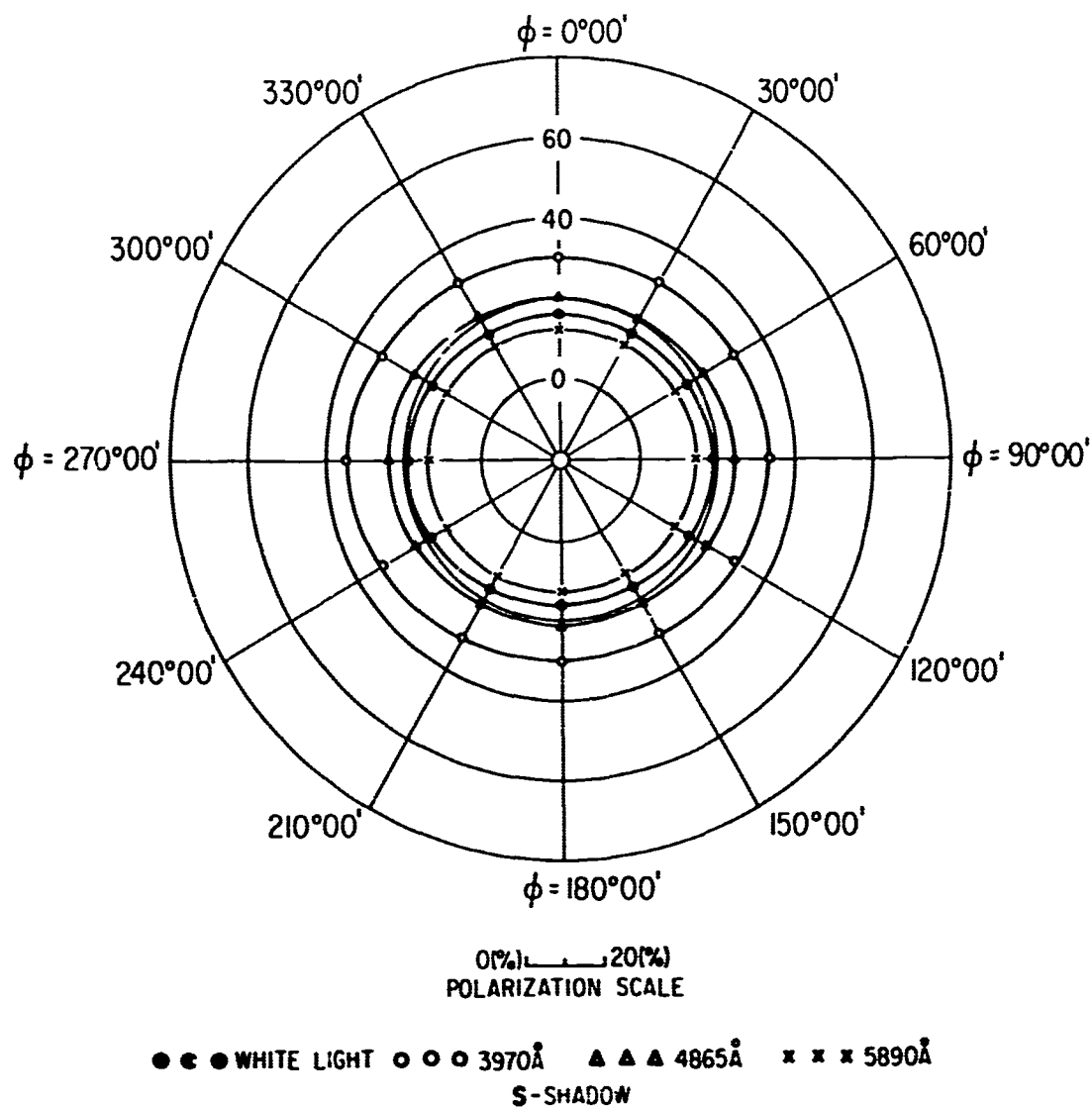


SAMPLE: DESERT SAND
 $\theta: 20^\circ$

ILLUMINATION: POLARIZED LIGHT \updownarrow
 $\theta: 0^\circ$

FIG 6I. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 19.85 - 0.41 \cos \varphi - 0.18 \cos 2\varphi + 0.33 \cos 3\varphi + 0.58 \cos 4\varphi - 0.26 \cos 5\varphi \\
 & + 0.30 \cos 6\varphi - 0.08 \sin \varphi + 0.10 \sin 2\varphi + 0.00 \sin 3\varphi - 0.13 \sin 4\varphi - 0.08 \sin 5\varphi
 \end{aligned}$$

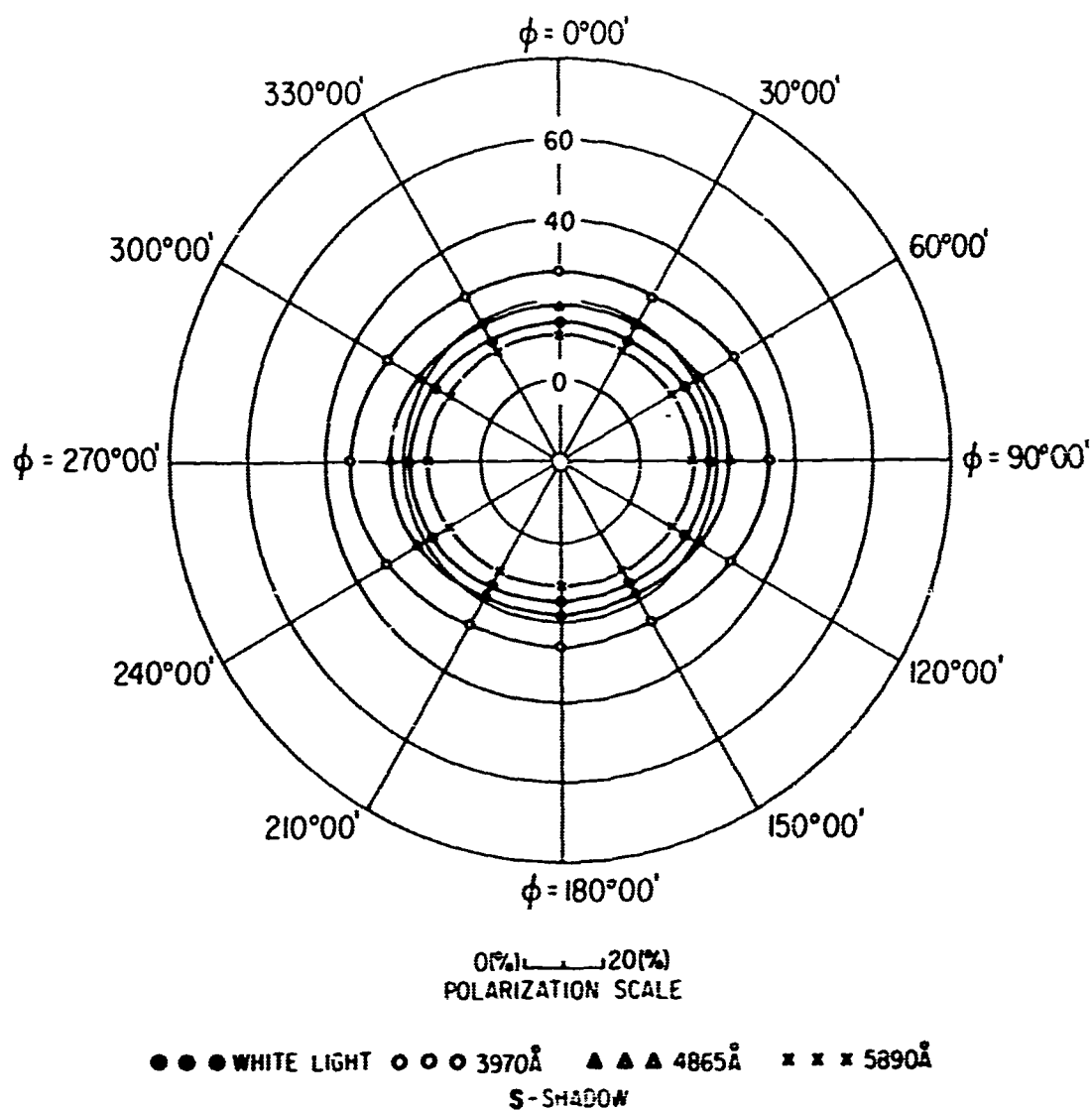


SAMPLE: DESERT SAND
 $\theta: 30^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta: 0^\circ$

FIG 62. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 17.69 - 0.06 \cos \varphi - 1.35 \cos 2\varphi + 0.03 \cos 3\varphi + 0.33 \cos 4\varphi - 0.02 \cos 5\varphi \\ - 0.05 \cos 6\varphi - 0.07 \sin \varphi - 0.09 \sin 2\varphi - 0.02 \sin 3\varphi - 0.17 \sin 4\varphi - 0.04 \sin 5\varphi$$



SAMPLE: DESERT SAND
 $\theta: 40^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta: 0^\circ$

FIG 63. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 16.12 - 0.20 \cos \varphi - 2.29 \cos 2\varphi + 0.05 \cos 3\varphi + 0.46 \cos 4\varphi + 0.00 \cos 5\varphi \\ + 0.13 \cos 6\varphi - 0.11 \sin \varphi + 0.46 \sin 2\varphi - 0.05 \sin 3\varphi - 0.14 \sin 4\varphi + 0.06 \sin 5\varphi$$

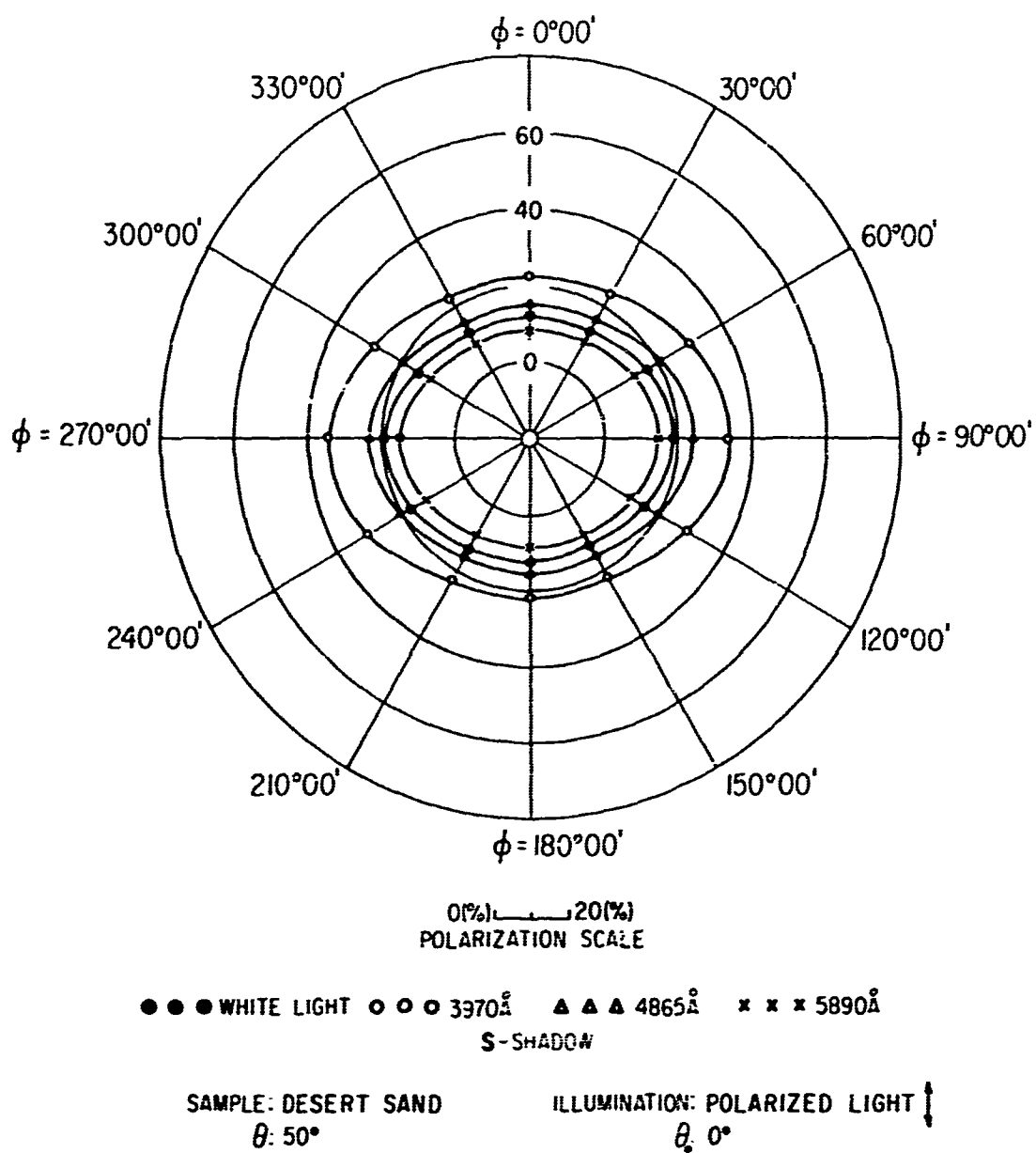


FIG. 64. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 14.83 - 0.19 \cos \varphi - 3.56 \cos 2\varphi + 0.05 \cos 3\varphi + 1.04 \cos 4\varphi + 0.04 \cos 5\varphi \\
 & + 0.17 \cos 6\varphi + 0.09 \sin \varphi + 0.39 \sin 2\varphi - 0.02 \sin 3\varphi - 0.22 \sin 4\varphi - 0.06 \sin 5\varphi
 \end{aligned}$$

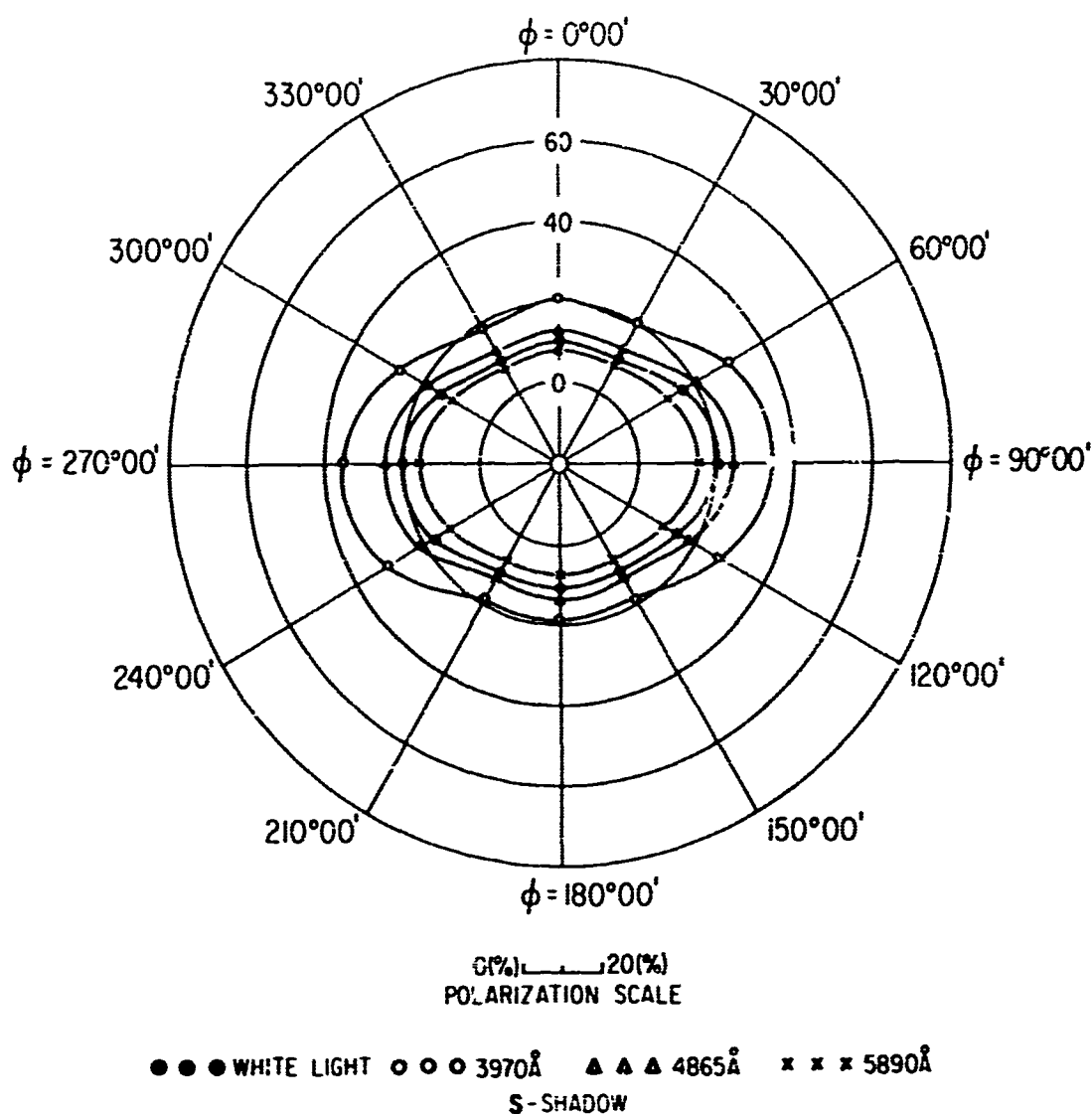
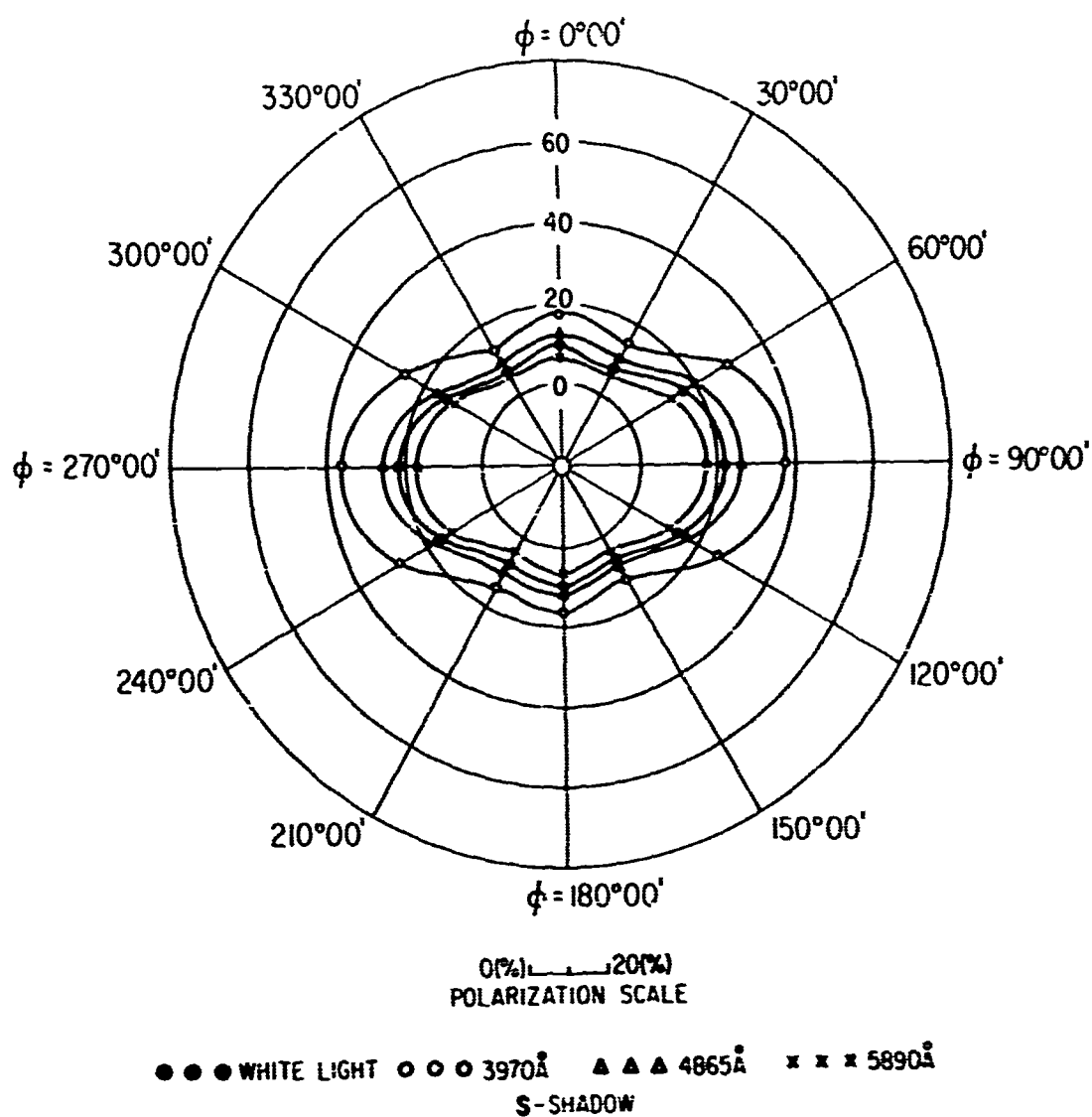


FIG. 65. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 13.88 - 0.18 \cos \varphi - 4.98 \cos 2\varphi - 0.02 \cos 3\varphi + 1.72 \cos 4\varphi + 0.05 \cos 5\varphi \\
 & + 0.67 \cos 6\varphi + 0.03 \sin \varphi + 0.75 \sin 2\varphi + 0.02 \sin 3\varphi - 0.52 \sin 4\varphi + 0.14 \sin 5\varphi
 \end{aligned}$$



SAMPLE: DESERT SAND
 $\theta: 70^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta: 0^\circ$

FIG 66. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 12.97 + 0.00 \cos \phi - 6.21 \cos 2\phi - 0.25 \cos 3\phi + 2.91 \cos 4\phi + 0.20 \cos 5\phi \\ + 1.20 \cos 6\phi - 0.30 \sin \phi + 1.30 \sin 2\phi - 0.15 \sin 3\phi - 1.10 \sin 4\phi + 0.35 \sin 5\phi$$

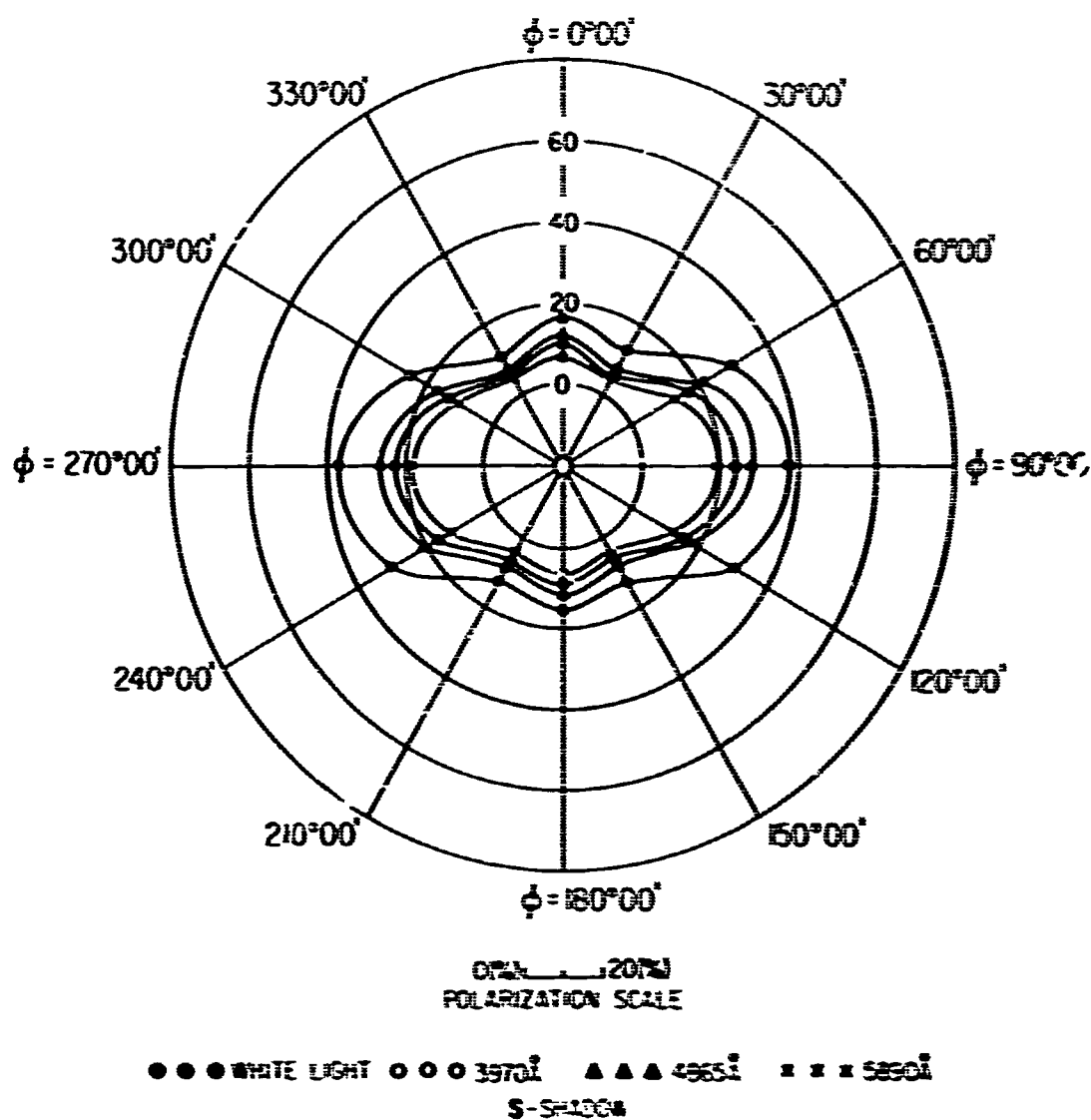


FIG 67. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 12.92 - 0.01 \cos \phi - 7.18 \cos 2\phi - 0.05 \cos 3\phi + 3.33 \cos 4\phi - 0.04 \cos 5\phi \\
 & + 2.07 \cos 6\phi + 0.11 \sin \phi + 1.01 \sin 2\phi - 0.15 \sin 3\phi - 0.92 \sin 4\phi + 1.40 \sin 5\phi
 \end{aligned}$$

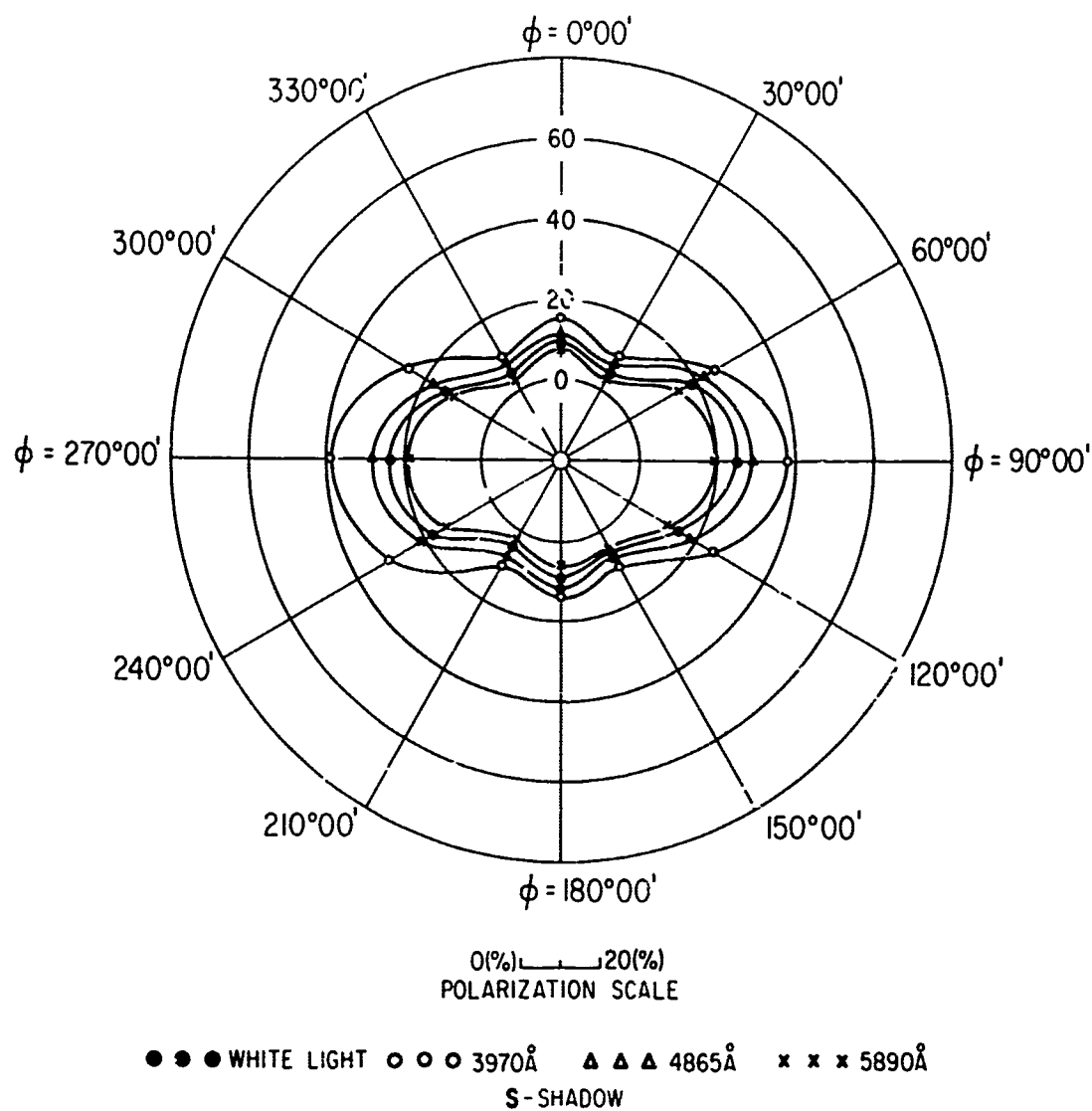
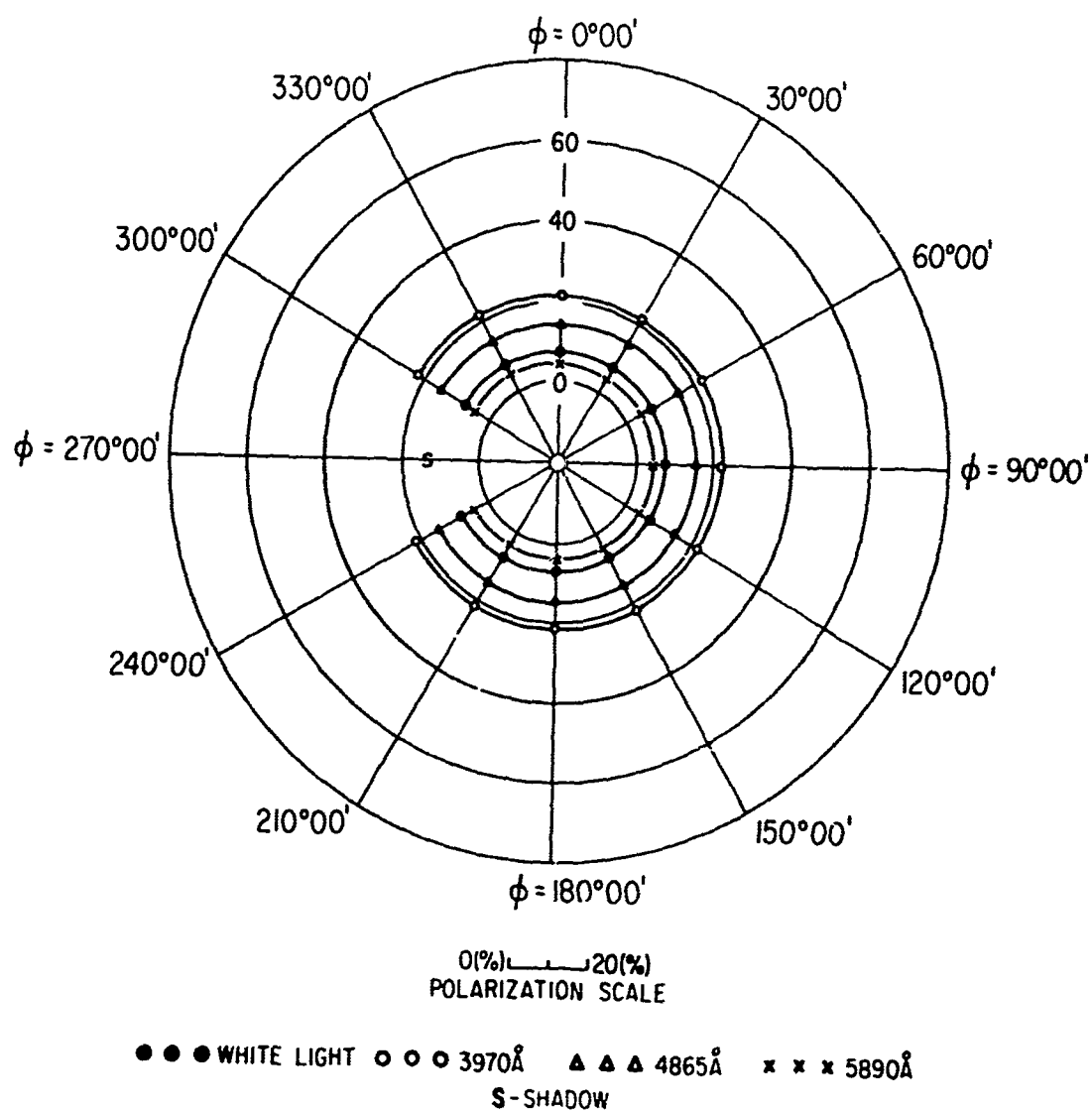


FIG 68. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

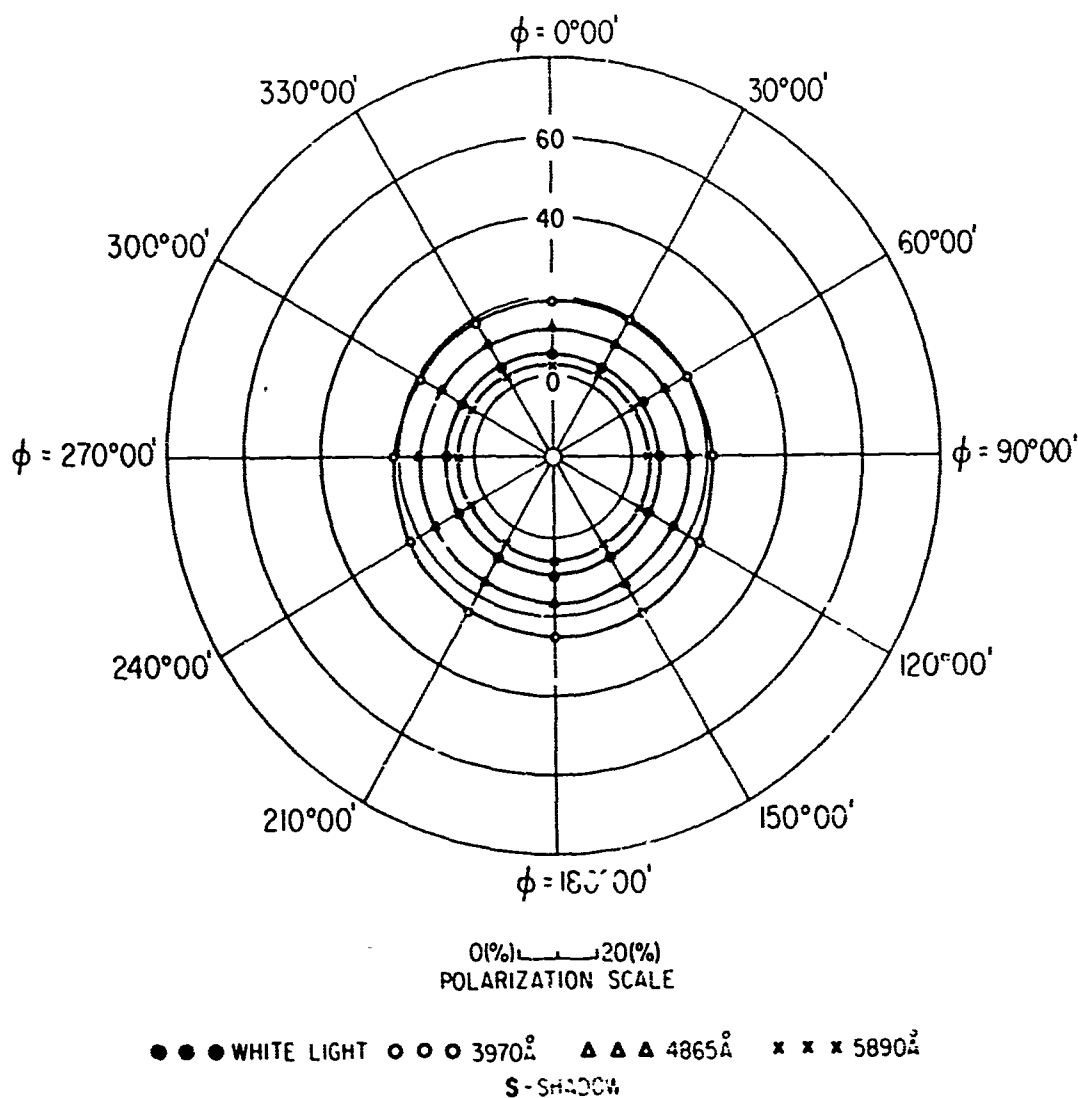
$$\begin{aligned}
 P(\phi) = & 12.90 - 0.19 \cos \phi - 8.42 \cos 2\phi + 0.20 \cos 3\phi + 4.21 \cos 4\phi + 0.04 \cos 5\phi \\
 & + 3.13 \cos 6\phi + 0.36 \sin \phi + 1.05 \sin 2\phi - 0.03 \sin 3\phi - 1.28 \sin 4\phi - 0.06 \sin 5\phi
 \end{aligned}$$



SAMPLE: DESERT SAND
 $\theta: 0^\circ$

ILLUMINATION: POLARIZED LIGHT ↑
 $\theta: 53^\circ$

FIG 69. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

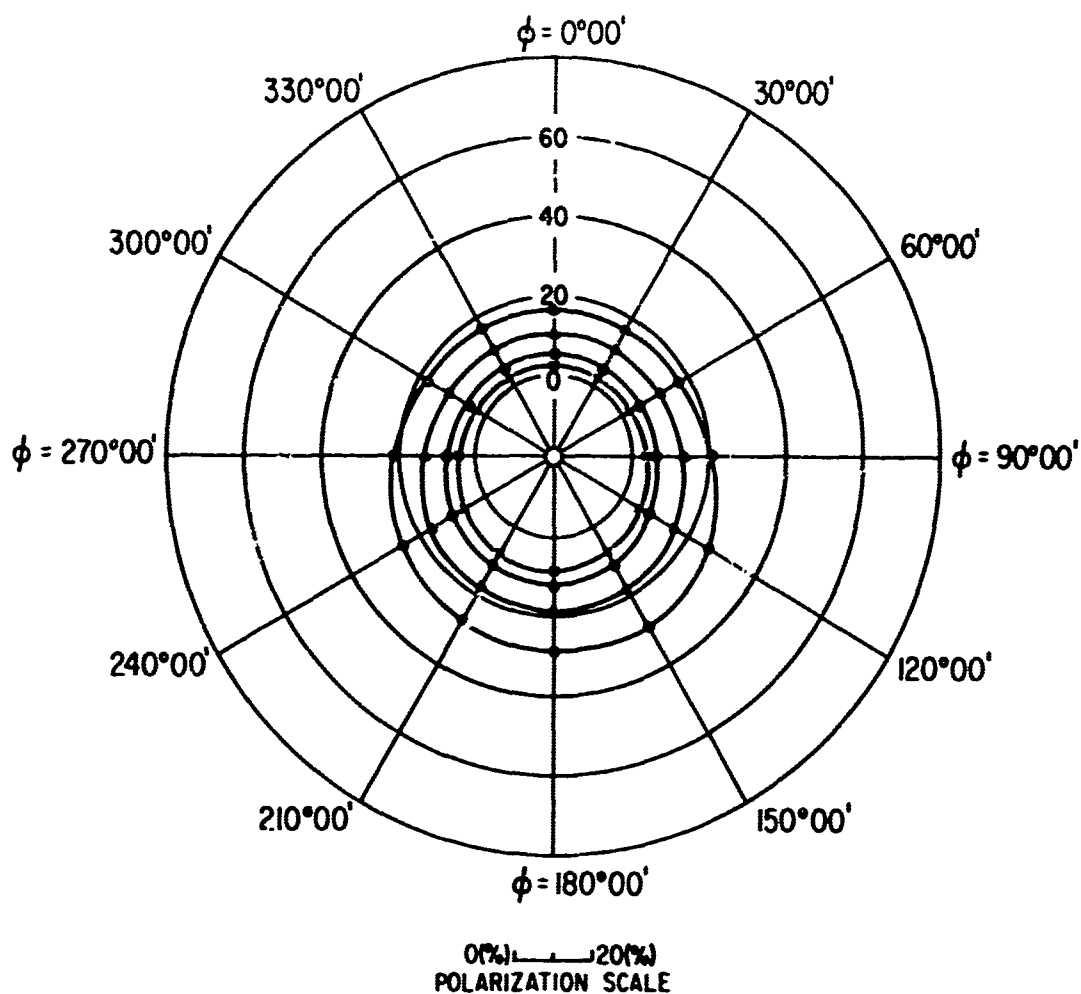


SAMPLE: DESERT SAND
 $\theta = 10^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta_i = 53^\circ$

FIG 70. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 7.52 - 2.02 \cos \varphi + 0.22 \cos 2\varphi - 0.17 \cos 3\varphi + 0.18 \cos 4\varphi - 0.21 \cos 5\varphi \\ - 0.05 \cos 6\varphi - 0.16 \sin \varphi - 0.10 \sin 2\varphi - 0.12 \sin 3\varphi + 0.07 \sin 4\varphi - 0.16 \sin 5\varphi$$



● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
S-SHADOW

SAMPLE: DESERT SAND
 $\theta: 23^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta: 53^\circ$

FIG. 71. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 6.69 - 3.90 \cos \varphi + 1.18 \cos 2\varphi + 0.55 \cos 3\varphi + 0.29 \cos 4\varphi - 0.30 \cos 5\varphi \\ + 0.10 \cos 6\varphi - 0.22 \sin \varphi + 0.16 \sin 2\varphi + 0.05 \sin 3\varphi - 0.02 \sin 4\varphi + 0.07 \sin 5\varphi$$

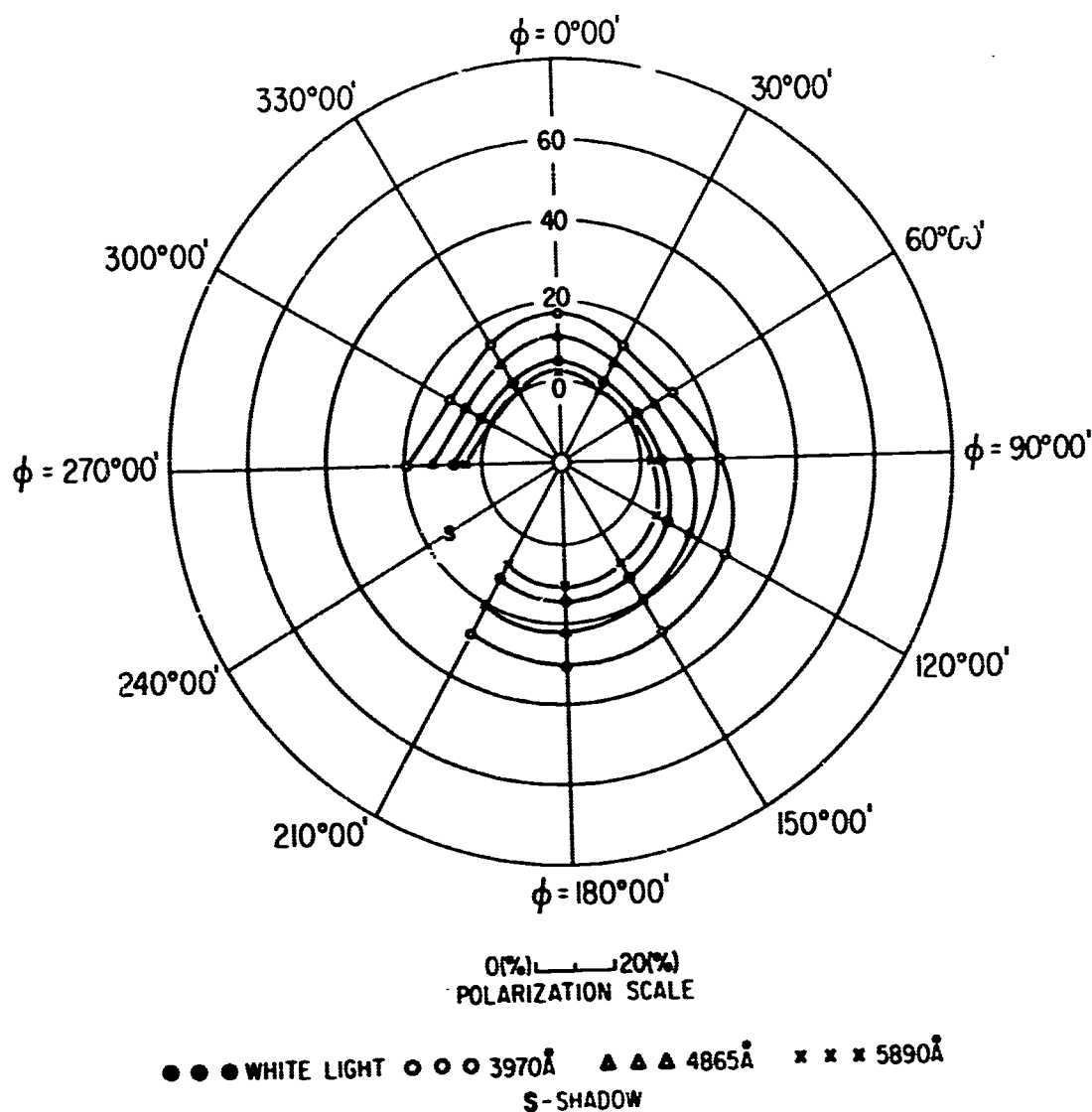


FIG 72. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 7.59 - 6.34 \cos \varphi + 1.48 \cos 2\varphi + 1.28 \cos 3\varphi + 0.83 \cos 4\varphi - 0.10 \cos 5\varphi \\ - 0.15 \cos 6\varphi - 0.44 \sin \varphi - 0.29 \sin 2\varphi + 0.13 \sin 3\varphi + 0.12 \sin 4\varphi - 0.03 \sin 5\varphi$$

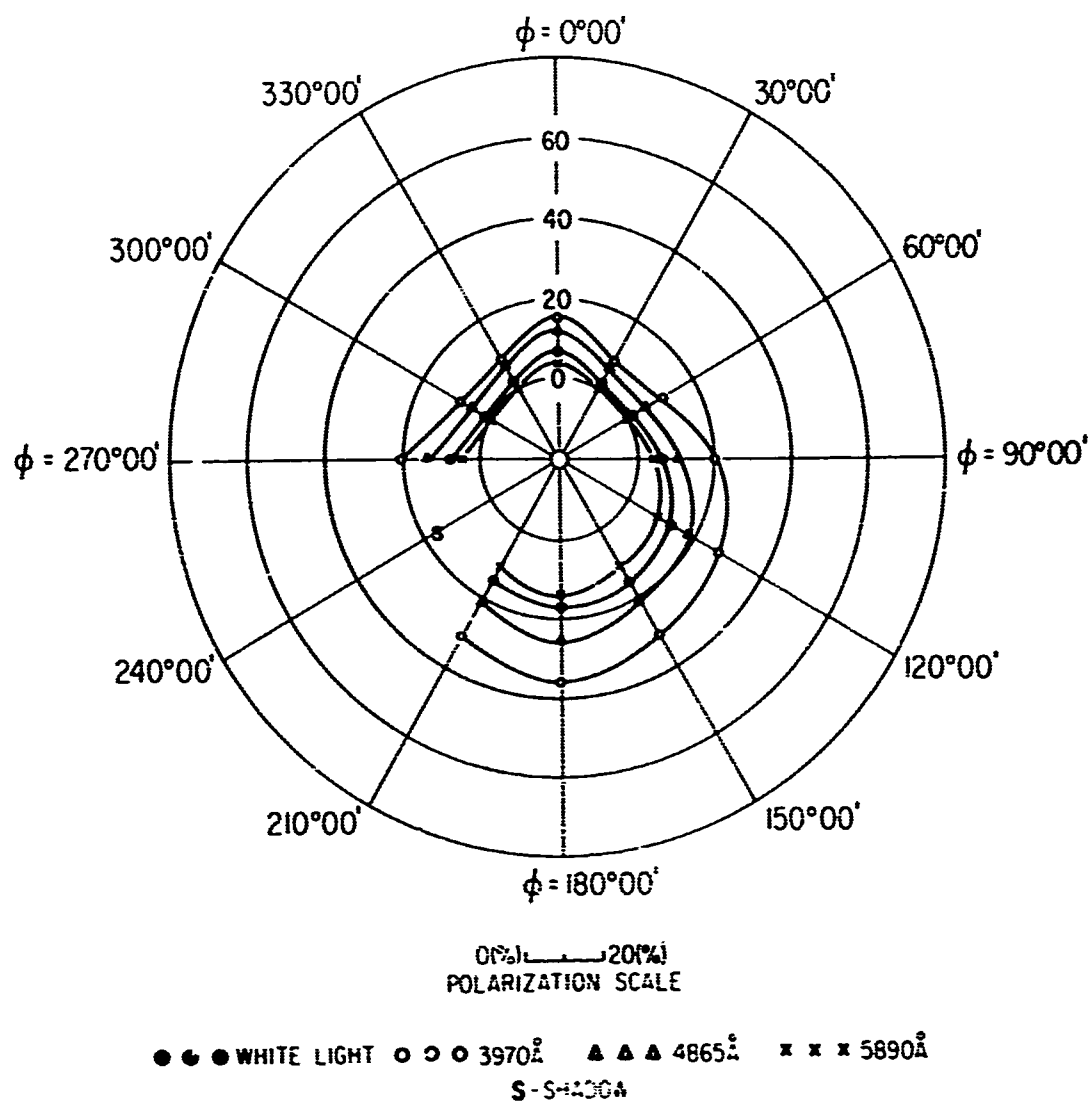
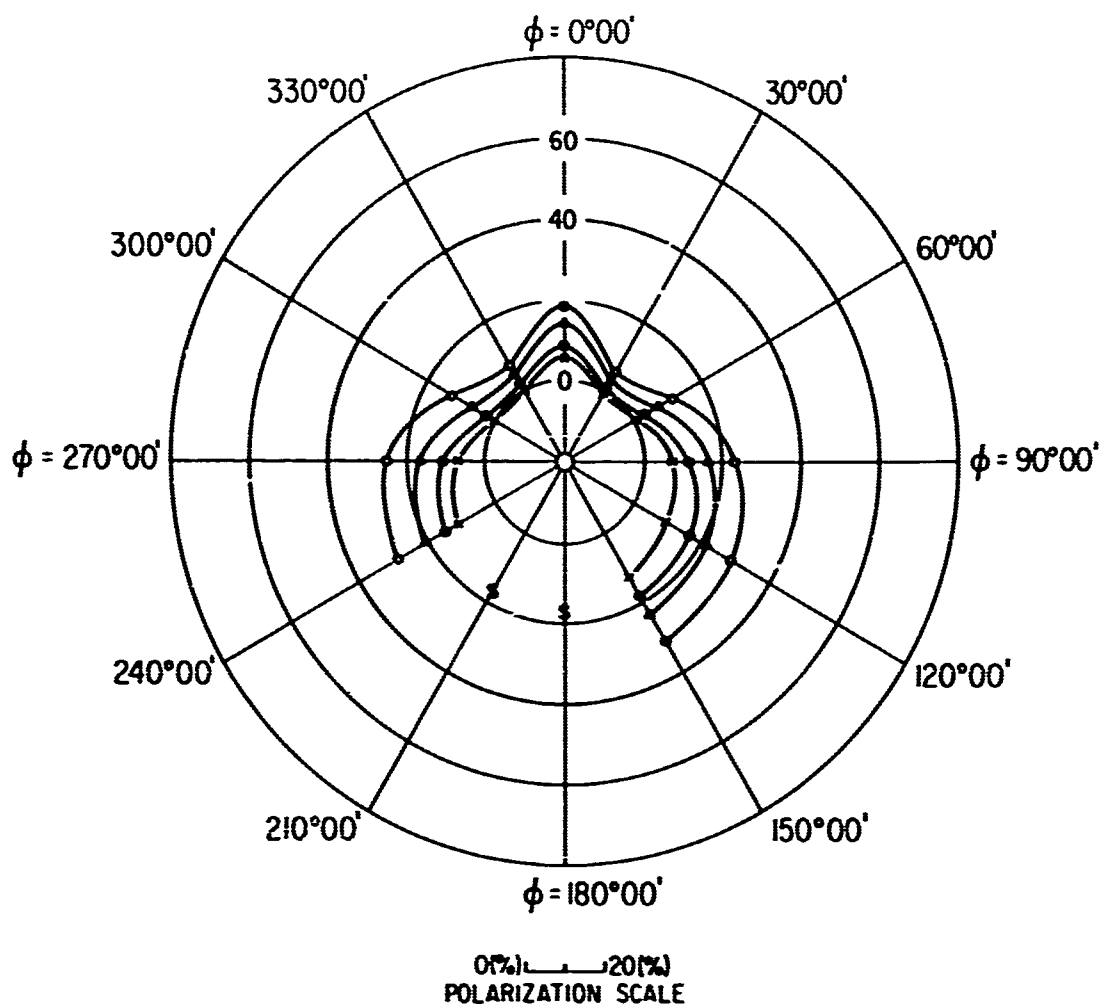


FIG 73. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 8.38 - 7.61 \cos \phi + 1.90 \cos 2\phi + 2.32 \cos 3\phi + 1.35 \cos 4\phi + 0.39 \cos 5\phi \\
 & - 0.25 \cos 6\phi - 0.02 \sin \phi - 0.18 \sin 2\phi + 0.00 \sin 3\phi + 0.03 \sin 4\phi - 0.23 \sin 5\phi
 \end{aligned}$$



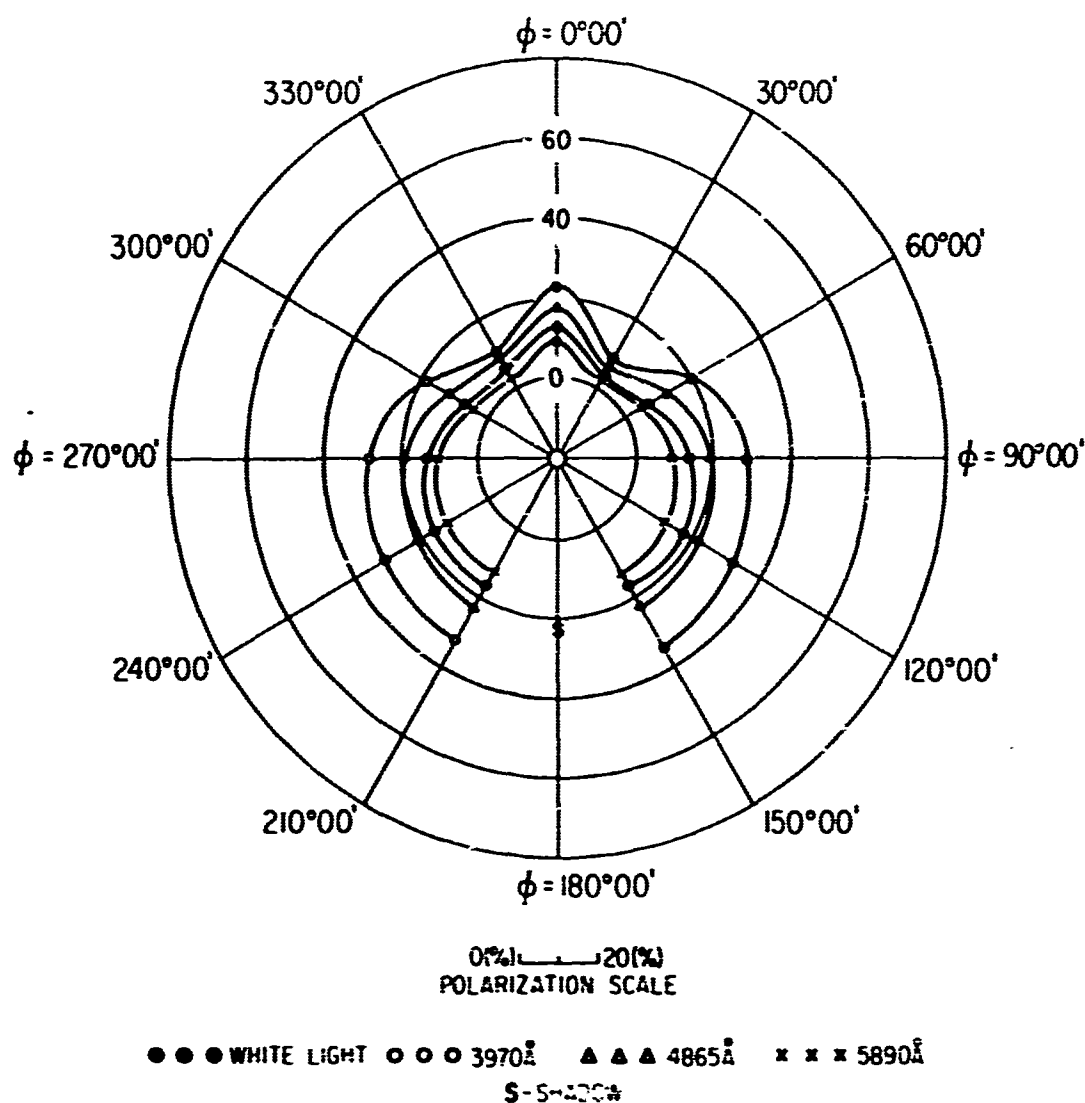
● ● ● WHITE LIGHT ○ ○ ○ 3970 Å ▲ ▲ ▲ 4865 Å x x x 5890 Å
 S-SHADOW

SAMPLE: DESERT SAND
 $\theta: 50^{\circ}$

ILLUMINATION: POLARIZED LIGHT
 $\theta_i: 53^{\circ}$

FIG. 74. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 10.01 - 8.07 \cos \varphi + 1.50 \cos 2\varphi + 1.41 \cos 3\varphi + 2.55 \cos 4\varphi + 1.52 \cos 5\varphi \\
 & - 0.03 \cos 6\varphi + 0.04 \sin \varphi - 0.28 \sin 2\varphi - 0.08 \sin 3\varphi - 0.09 \sin 4\varphi + 0.00 \sin 5\varphi
 \end{aligned}$$

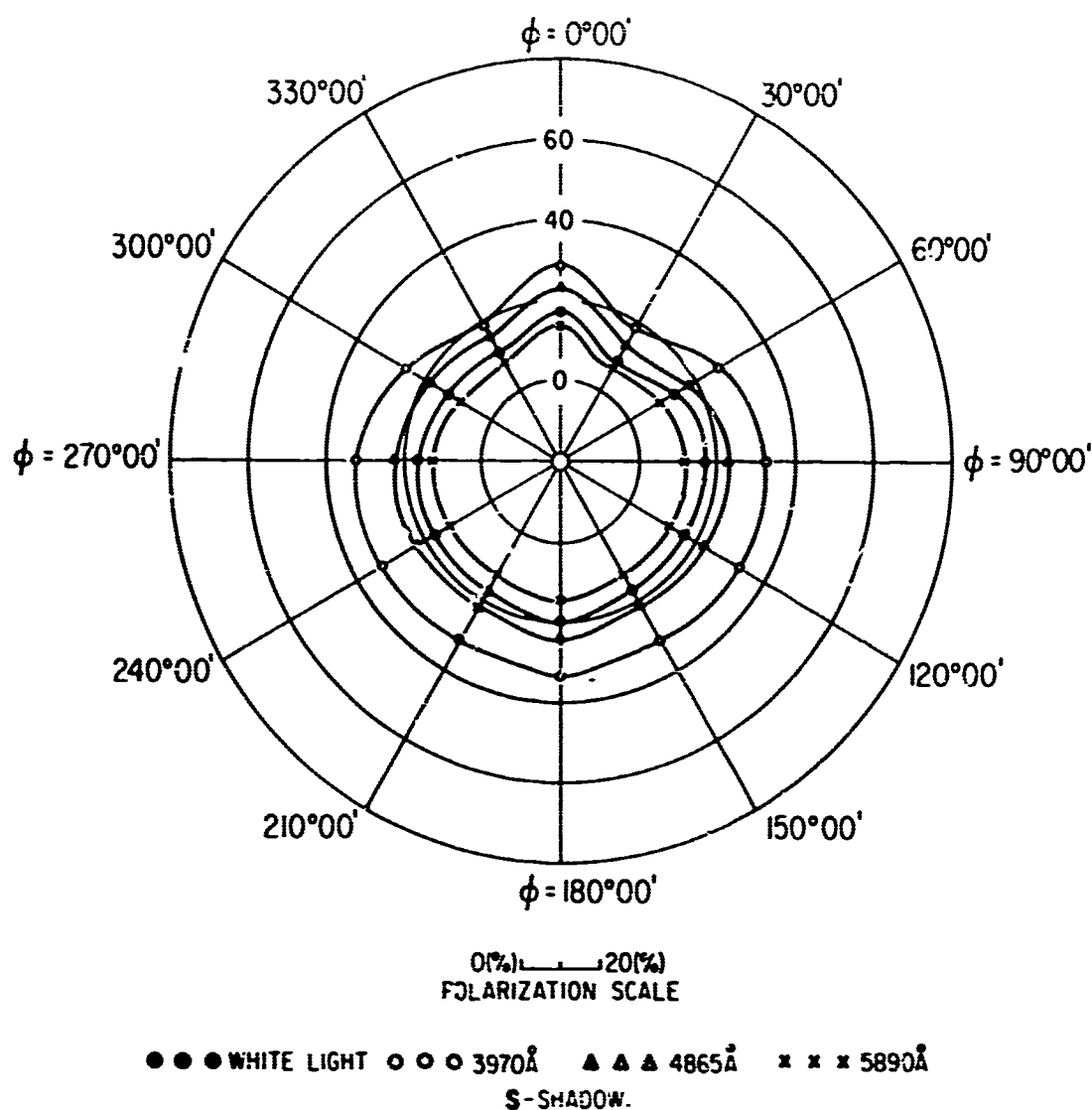


SAMPLE. DESERT SAND
 $\theta: 60^{\circ}$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta_i 53^{\circ}$

FIG 75. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 11.18 - 5.50 \cos \varphi + 0.17 \cos 2\varphi + 2.52 \cos 3\varphi + 1.90 \cos 4\varphi + 1.13 \cos 5\varphi \\
 & + 1.02 \cos 6\varphi - 0.12 \sin \varphi + 0.00 \sin 2\varphi - 0.33 \sin 3\varphi - 0.16 \sin 4\varphi - 0.01 \sin 5\varphi
 \end{aligned}$$

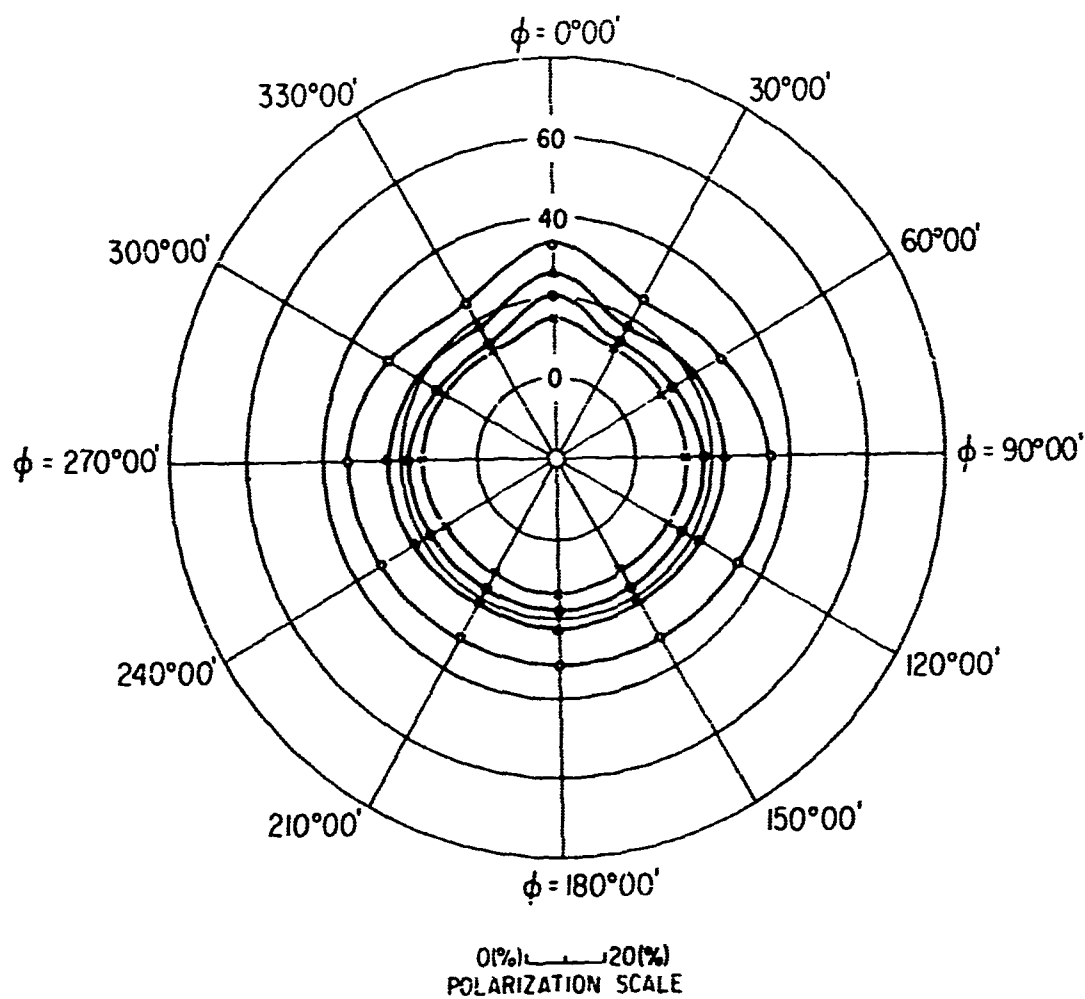


SAMPLE: DESERT SAND
 $\theta: 70^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta_i: 53^\circ$

FIG. 76. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 14.34 - 2.67 \cos \phi + 0.03 \cos 2\phi + 0.83 \cos 3\phi + 2.30 \cos 4\phi + 0.67 \cos 5\phi \\
 & + 2.07 \cos 6\phi - 0.14 \sin \phi + 0.03 \sin 2\phi - 0.17 \sin 3\phi - 0.52 \sin 4\phi - 0.58 \sin 5\phi
 \end{aligned}$$



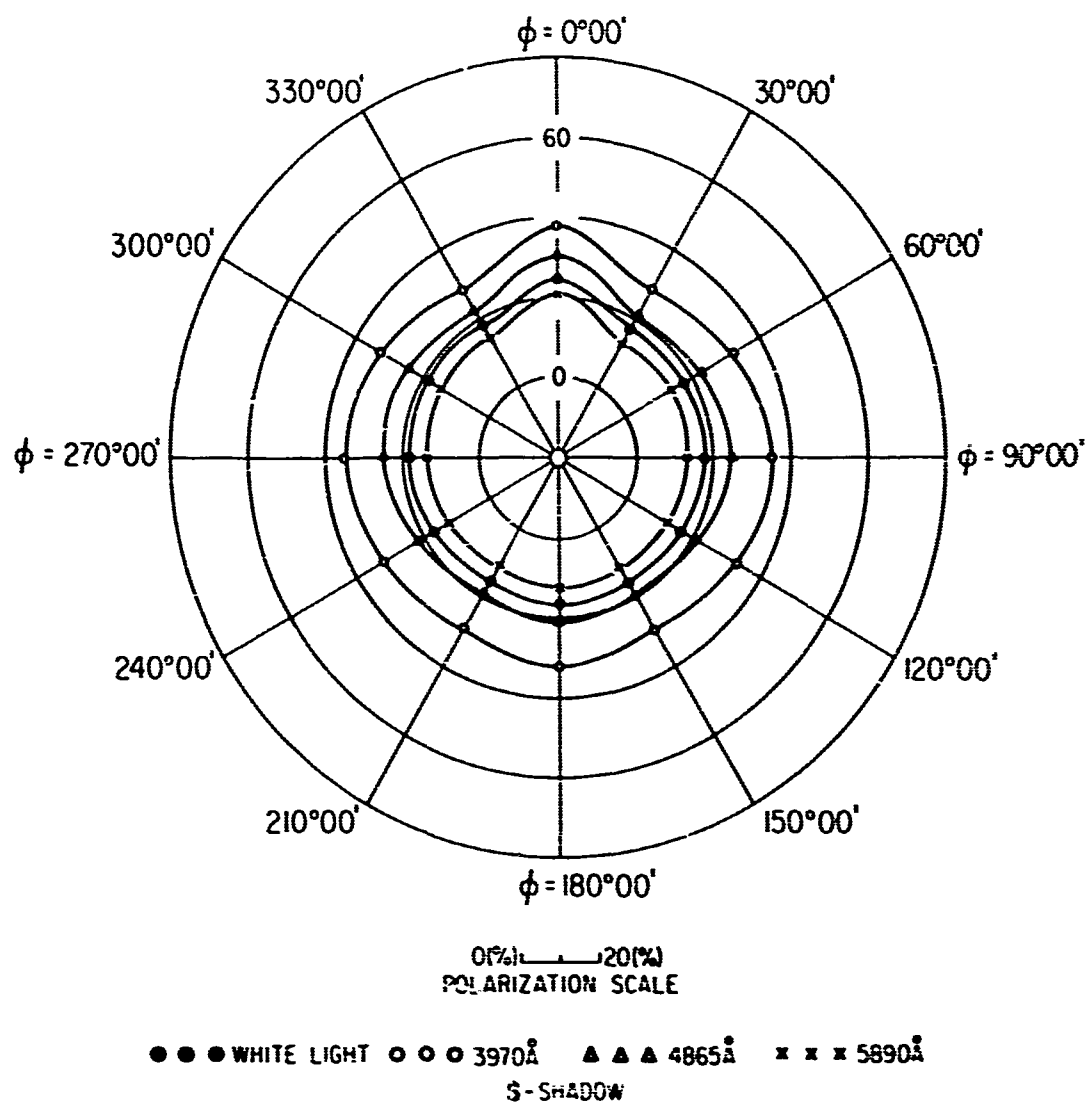
● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
 S-SHADOW

SAMPLE: DESERT SAND
 $\theta: 75^{\circ}$

ILLUMINATION: POLARIZED LIGHT
 $\theta: 53^{\circ}$

FIG 77 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 16.88 - 0.80 \cos \varphi - 0.15 \cos 2\varphi + 1.55 \cos 3\varphi + 2.30 \cos 4\varphi + 0.70 \cos 5\varphi \\
 & + 0.88 \cos 6\varphi - 0.34 \sin \varphi - 0.18 \sin 2\varphi + 0.13 \sin 3\varphi - 0.17 \sin 4\varphi + 0.07 \sin 5\varphi
 \end{aligned}$$

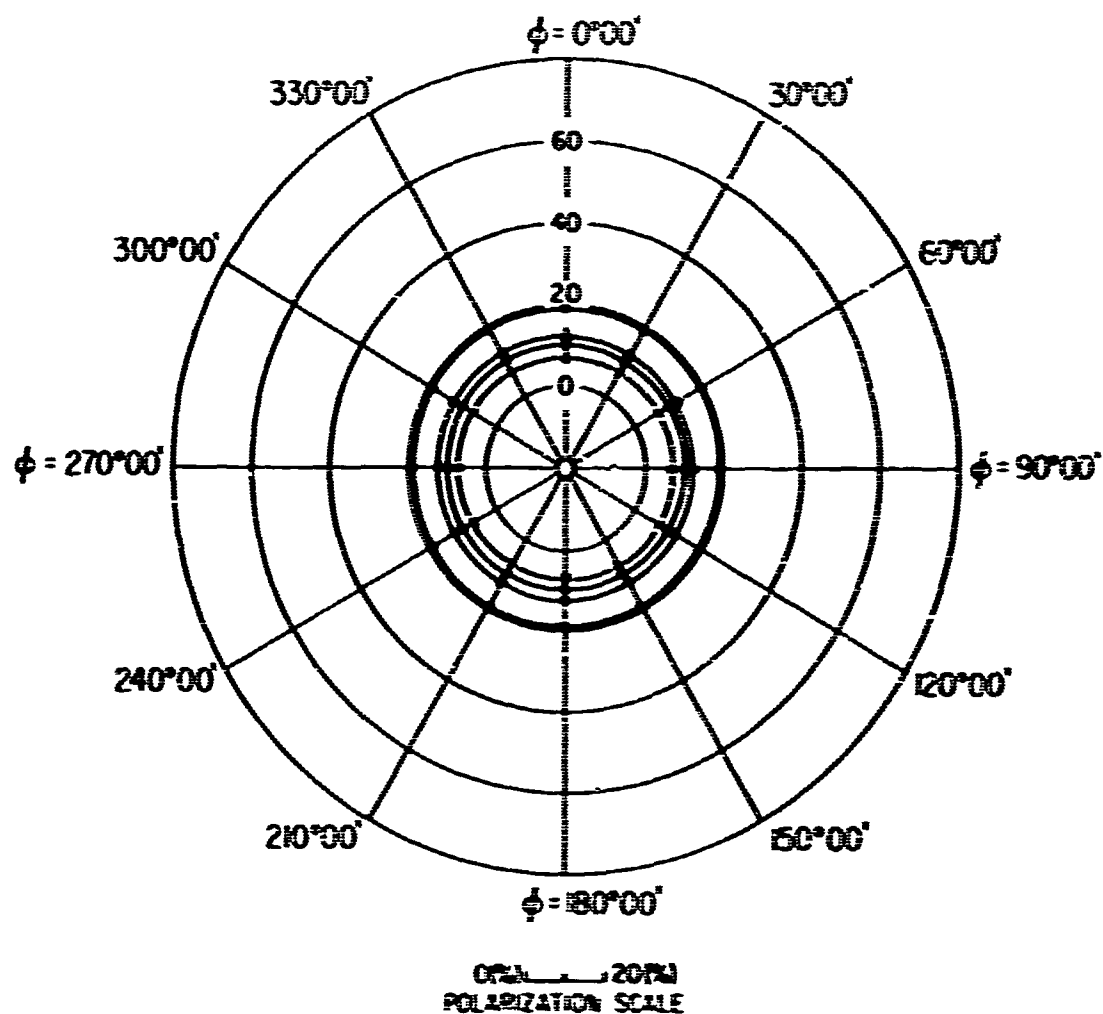


SAMPLE. DESERT SAND
 $\theta: 80^\circ$

ILLUMINATION: POLARIZED LIGHT ↑
 $\theta_i: 53^\circ$

FIG 78. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 18.04 + 2.48 \cos \phi + 0.60 \cos 2\phi + 1.03 \cos 3\phi + 1.48 \cos 4\phi + 0.49 \cos 5\phi \\
 & + 1.65 \cos 6\phi - 0.57 \sin \phi - 0.46 \sin 2\phi + 0.25 \sin 3\phi - 0.16 \sin 4\phi + 0.06 \sin 5\phi
 \end{aligned}$$

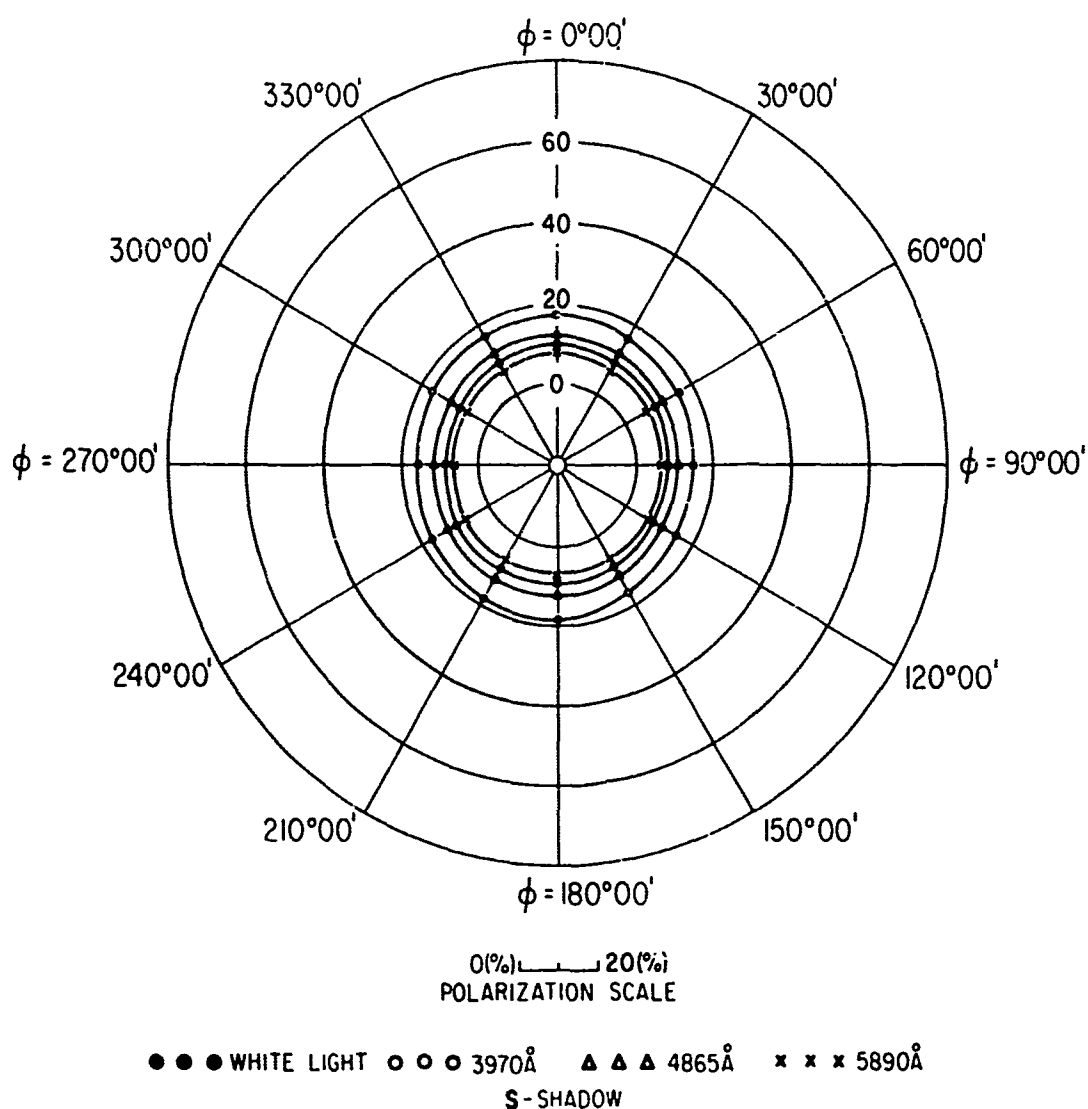


● ● ● WHITE LIGHT ○ ○ ○ 3970 Å ▲ ▲ ▲ 4861 Å × × × 5890 Å
 S-SHADOW

SAMPLE: DESERT SAND
 $\theta. 0^\circ$

ILLUMINATION: POLARIZED LIGHT
 $\theta. 78^\circ 30'$

FIG 79. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT



SAMPLE. DESERT SAND
 $\theta: 10^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta_i 78^\circ 30'$

FIG 80. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 9.61 - 0.18 \cos \varphi + 0.94 \cos 2\varphi - 0.10 \cos 3\varphi - 0.11 \cos 4\varphi + 0.06 \cos 5\varphi \\ - 0.08 \cos 6\varphi - 0.12 \sin \varphi - 0.02 \sin 2\varphi - 0.25 \sin 3\varphi - 0.02 \sin 4\varphi - 0.12 \sin 5\varphi$$

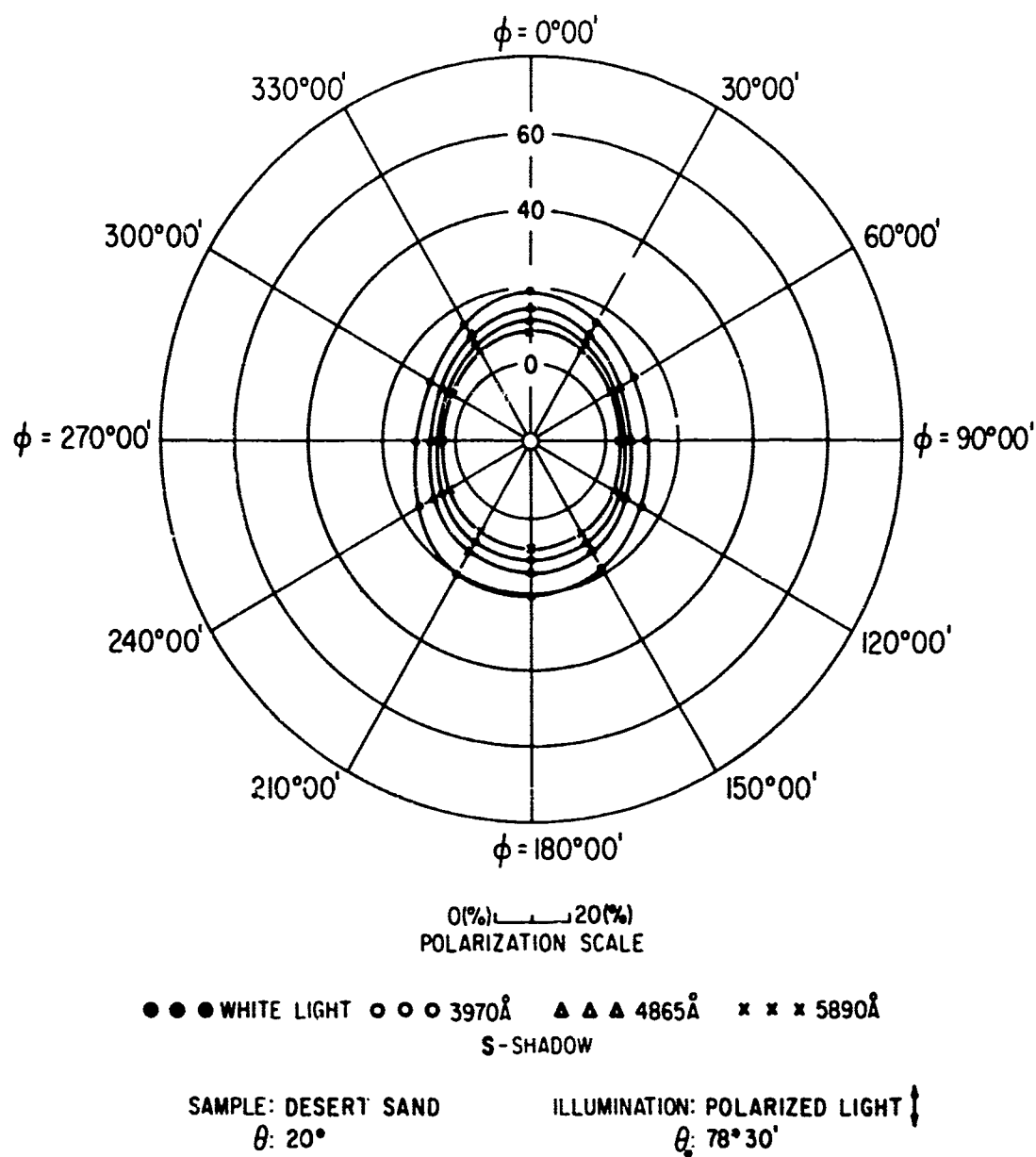


FIG 81. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 8.70 - 0.47 \cos \varphi + 3.29 \cos 2\varphi + 0.72 \cos 3\varphi - 0.12 \cos 4\varphi - 0.09 \cos 5\varphi \\
 & - 0.03 \cos 6\varphi - 0.11 \sin \varphi - 0.04 \sin 2\varphi - 0.22 \sin 3\varphi - 0.06 \sin 4\varphi - 0.11 \sin 5\varphi
 \end{aligned}$$

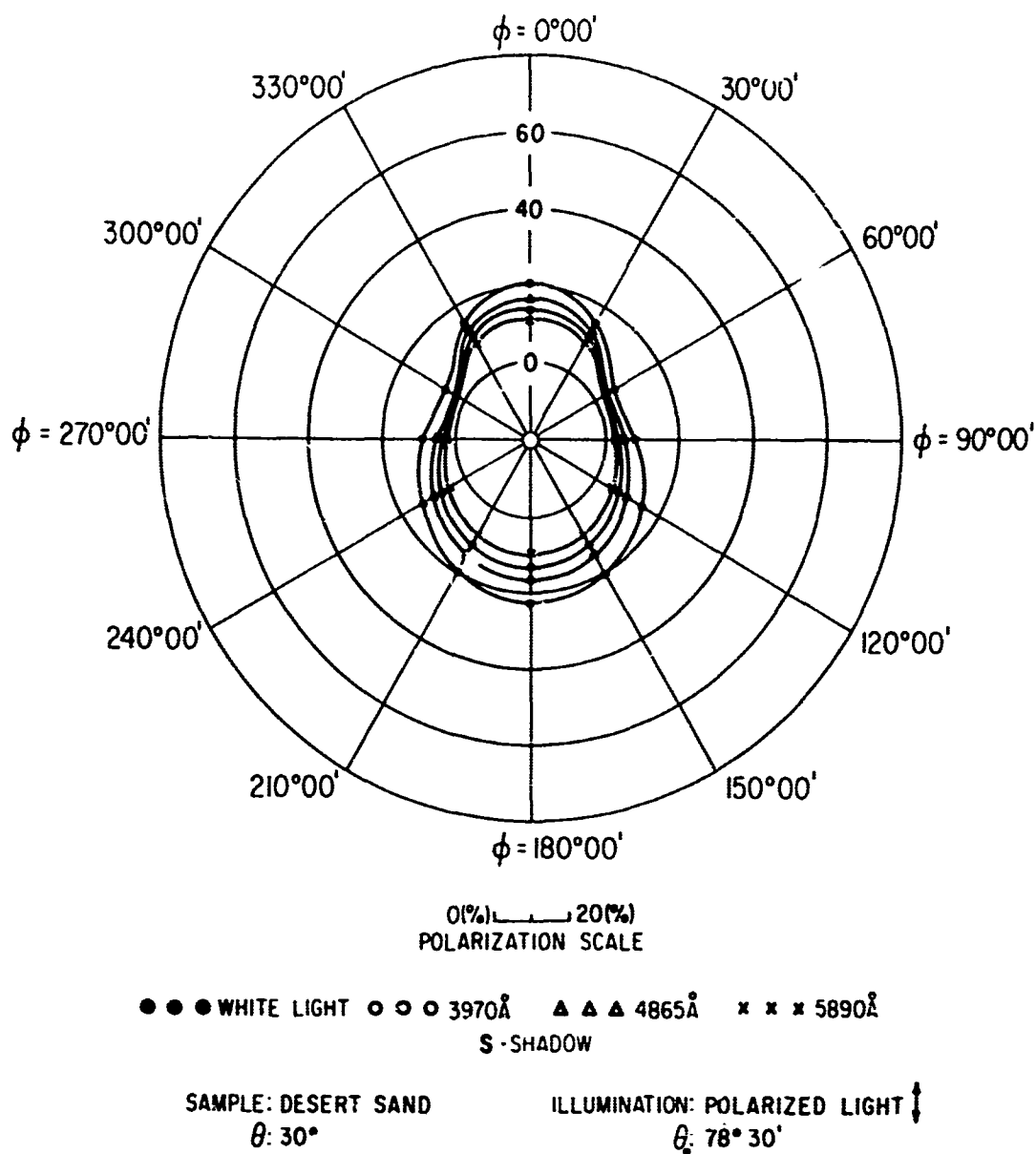
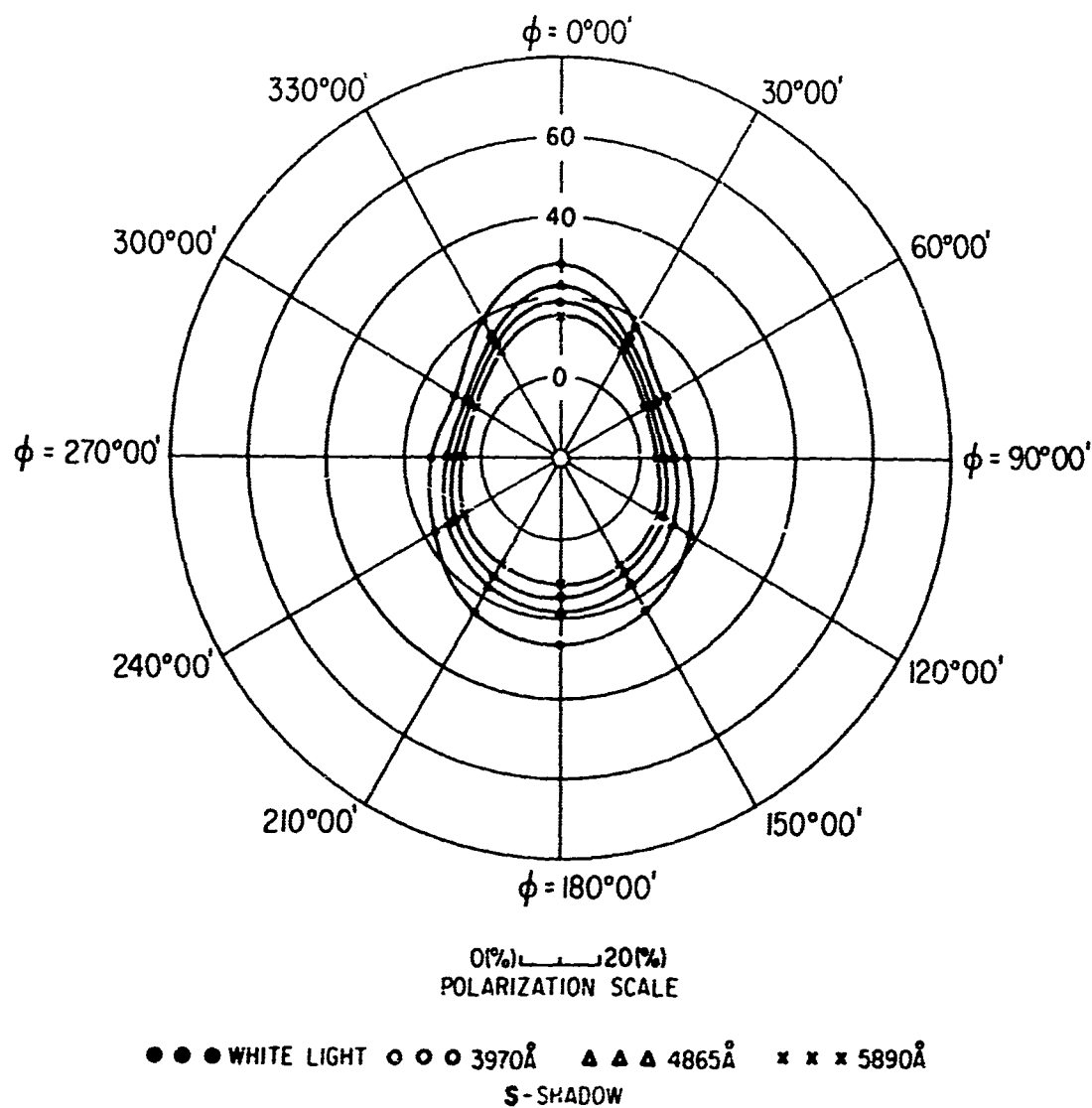


FIG 82. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 8.64 - 0.25 \cos \varphi + 5.66 \cos 2\varphi + 1.95 \cos 3\varphi + 0.33 \cos 4\varphi - 0.28 \cos 5\varphi \\
 & - 0.38 \cos 6\varphi - 0.05 \sin \varphi + 0.06 \sin 2\varphi - 0.10 \sin 3\varphi + 0.06 \sin 4\varphi - 0.05 \sin 5\varphi
 \end{aligned}$$



SAMPLE: DESERT SAND
 $\theta: 40^{\circ}$

ILLUMINATION: POLARIZED LIGHT
 $\theta: 78^{\circ}30'$

FIG 83. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 11.57 - 0.32 \cos \varphi + 5.15 \cos 2\varphi + 2.03 \cos 3\varphi + 0.88 \cos 4\varphi + 0.08 \cos 5\varphi \\
 & + 0.00 \cos 6\varphi + 0.03 \sin \varphi + 0.09 \sin 2\varphi + 0.07 \sin 3\varphi + 0.09 \sin 4\varphi + 0.03 \sin 5\varphi
 \end{aligned}$$

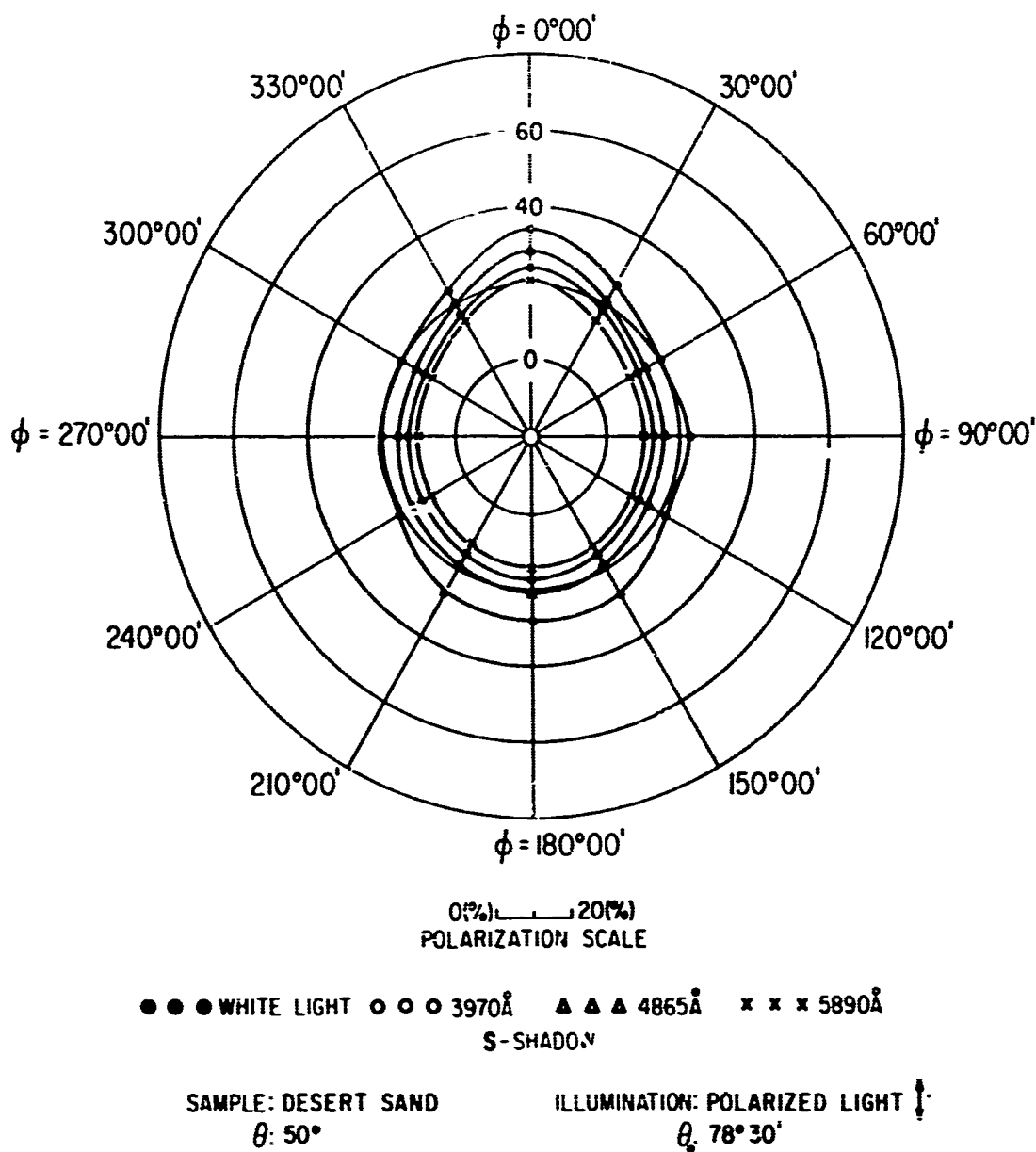


FIG 84. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 15.82 + 1.57 \cos \varphi + 4.57 \cos 2\varphi + 1.77 \cos 3\varphi + 1.33 \cos 4\varphi + 1.39 \cos 5\varphi \\ + 0.57 \cos 6\varphi + 0.08 \sin \varphi + 0.14 \sin 2\varphi + 0.16 \sin 3\varphi + 0.14 \sin 4\varphi + 0.08 \sin 5\varphi$$

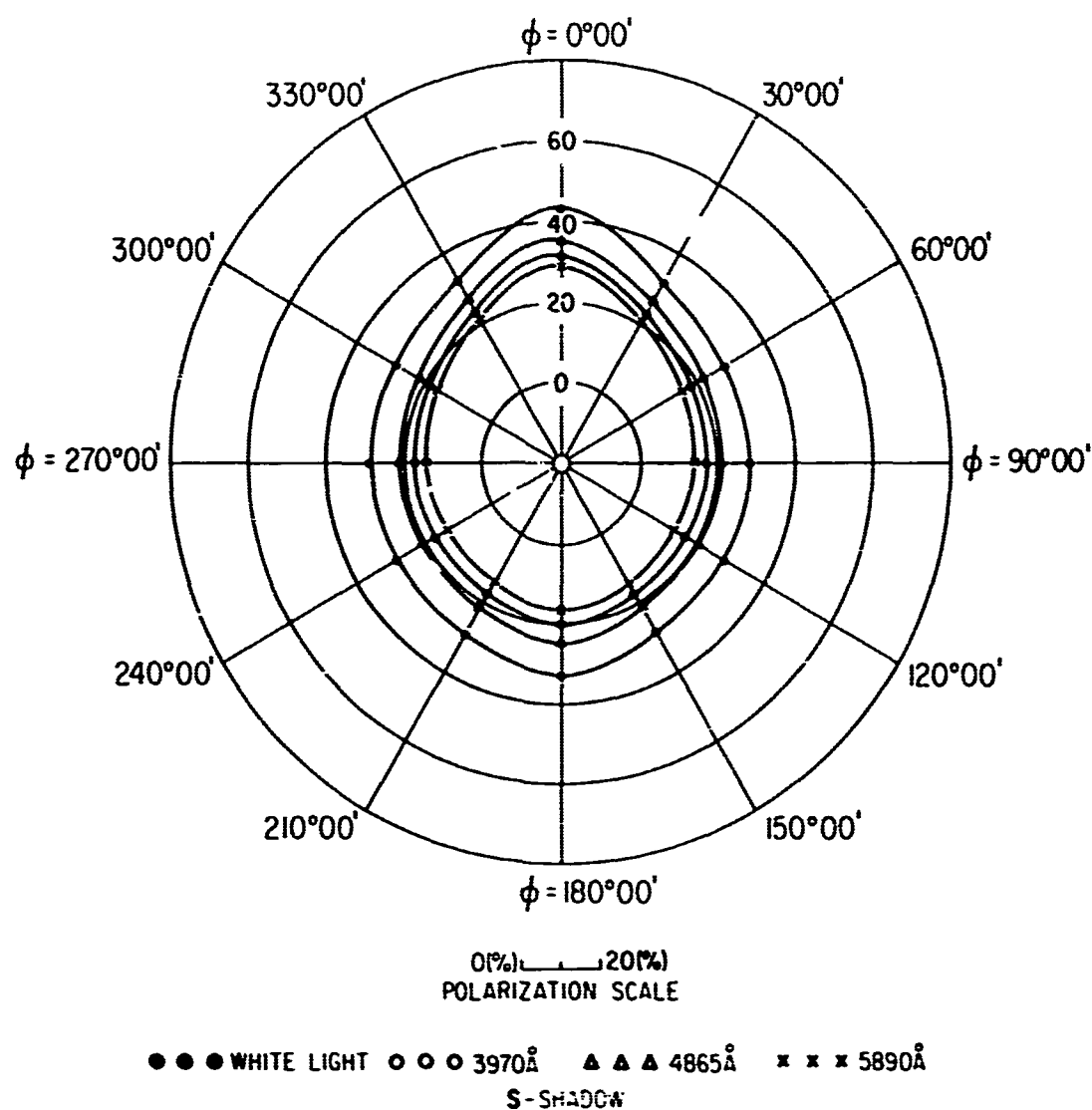


FIG 85. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 20.97 + 4.51 \cos \phi + 4.58 \cos 2\phi + 1.37 \cos 3\phi + 1.78 \cos 4\phi + 2.00 \cos 5\phi \\
 & + 1.33 \cos 6\phi + 0.15 \sin \phi + 0.29 \sin 2\phi + 0.30 \sin 3\phi + 0.29 \sin 4\phi + 0.15 \sin 5\phi
 \end{aligned}$$

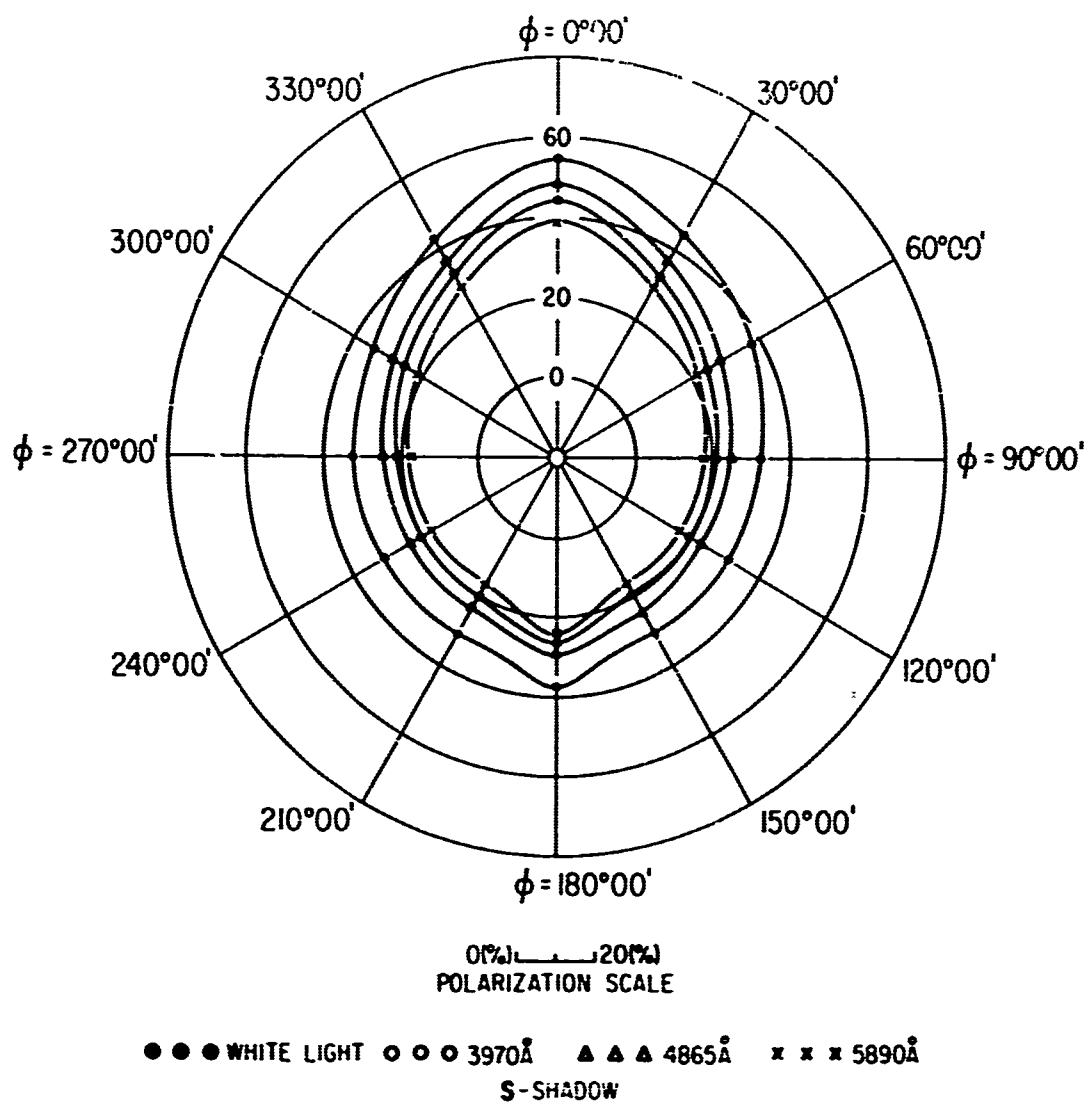


FIG 86. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 26.48 + 7.60 \cos \varphi + 5.42 \cos 2\varphi + 1.53 \cos 3\varphi + 2.62 \cos 4\varphi + 0.56 \cos 5\varphi \\
 & + 1.37 \cos 6\varphi + 0.18 \sin \varphi + 0.18 \sin 2\varphi + 0.37 \sin 3\varphi + 0.18 \sin 4\varphi - 1.77 \sin 5\varphi
 \end{aligned}$$

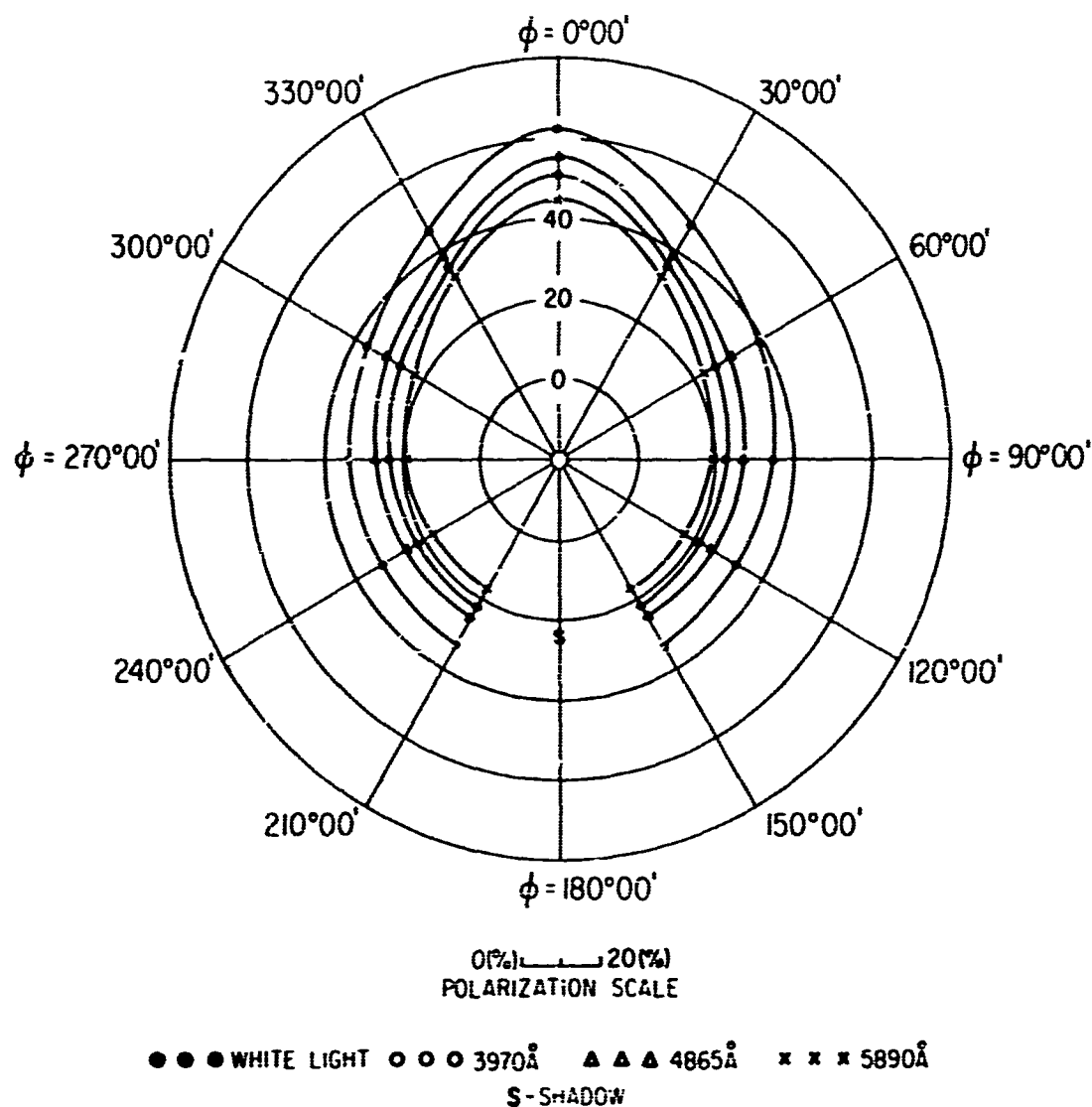
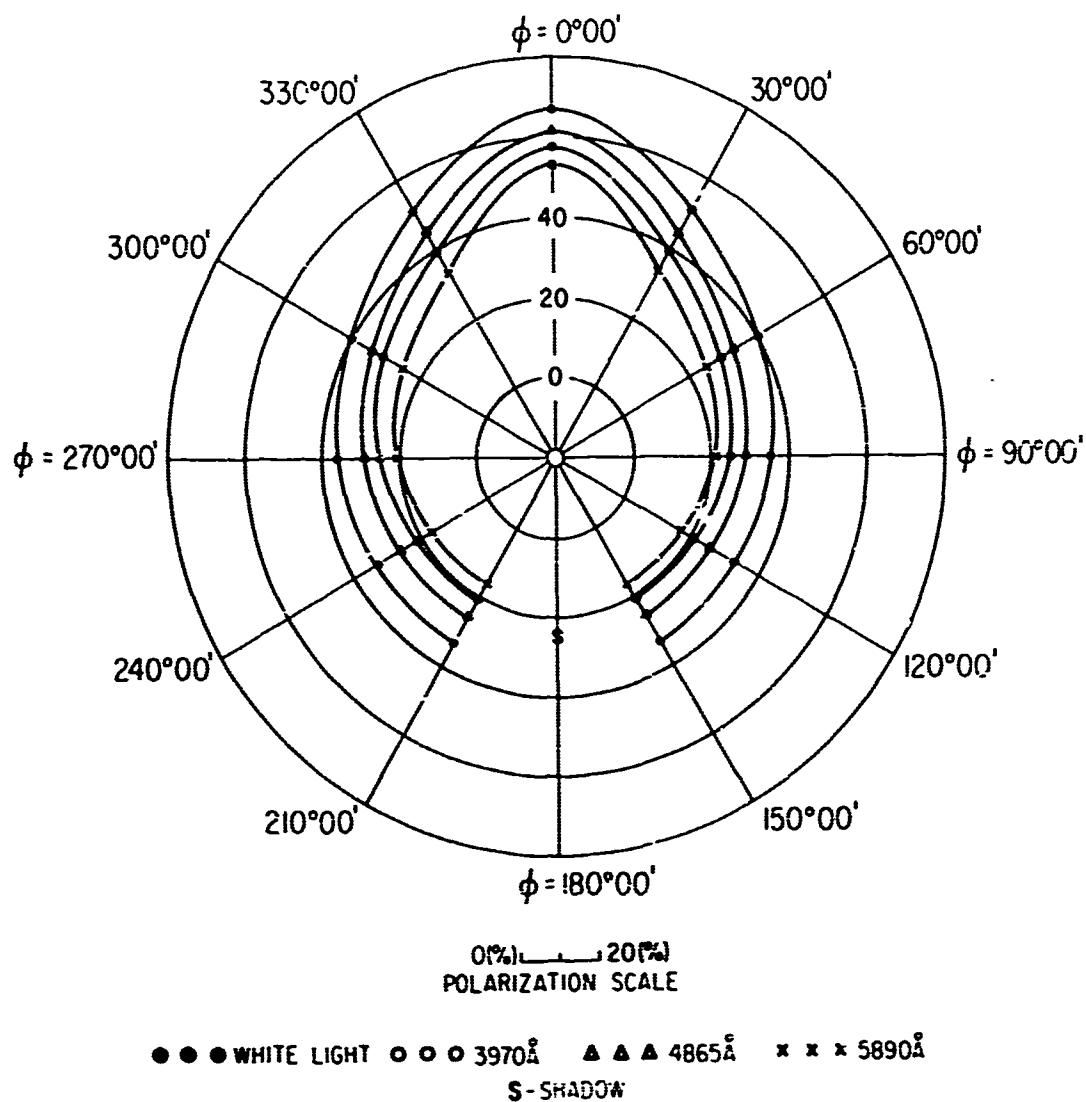


FIG 87. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 28.09 + 11.03 \cos \varphi + 6.00 \cos 2\varphi + 2.52 \cos 3\varphi + 2.13 \cos 4\varphi + 1.10 \cos 5\varphi \\
 & + 0.85 \cos 6\varphi - 0.08 \sin \varphi + 0.00 \sin 2\varphi + 0.00 \sin 3\varphi + 0.00 \sin 4\varphi + 0.00 \sin 5\varphi
 \end{aligned}$$

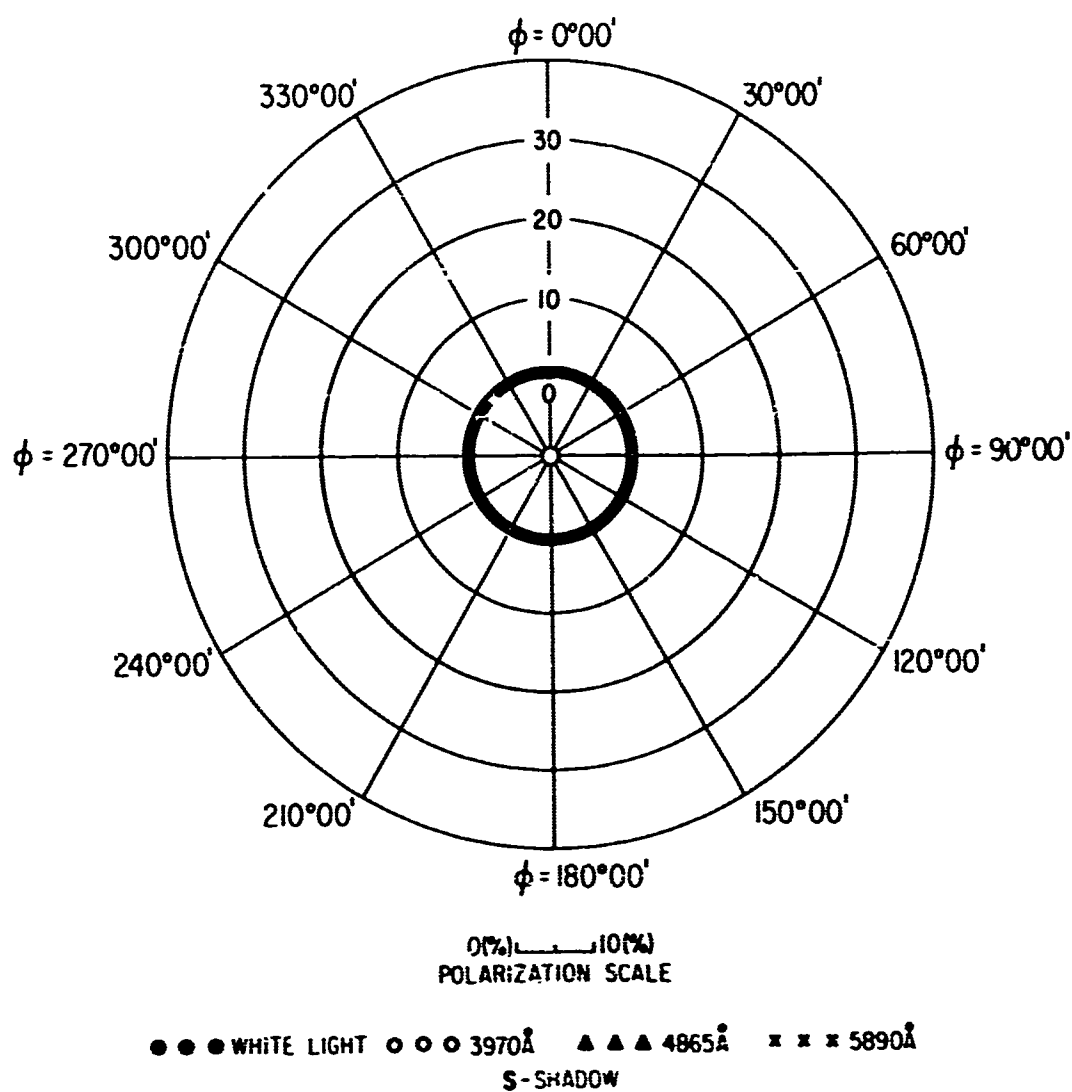


SAMPLE: DESERT SAND
 $\theta: 80^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta_i 78^\circ 30'$

FIG 88. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 29.45 + 12.66 \cos \phi + 7.2 \cos 2\phi + 3.37 \cos 3\phi + 2.80 \cos 4\phi + 2.27 \cos 5\phi \\
 & + 1.70 \cos 6\phi + 0.20 \sin \phi + 0.34 \sin 2\phi + 0.40 \sin 3\phi + 0.34 \sin 4\phi + 0.20 \sin 5\phi
 \end{aligned}$$



SAMPLE: WHITE SAND
 $\theta, 10^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta, 0^\circ$

FIG 89. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

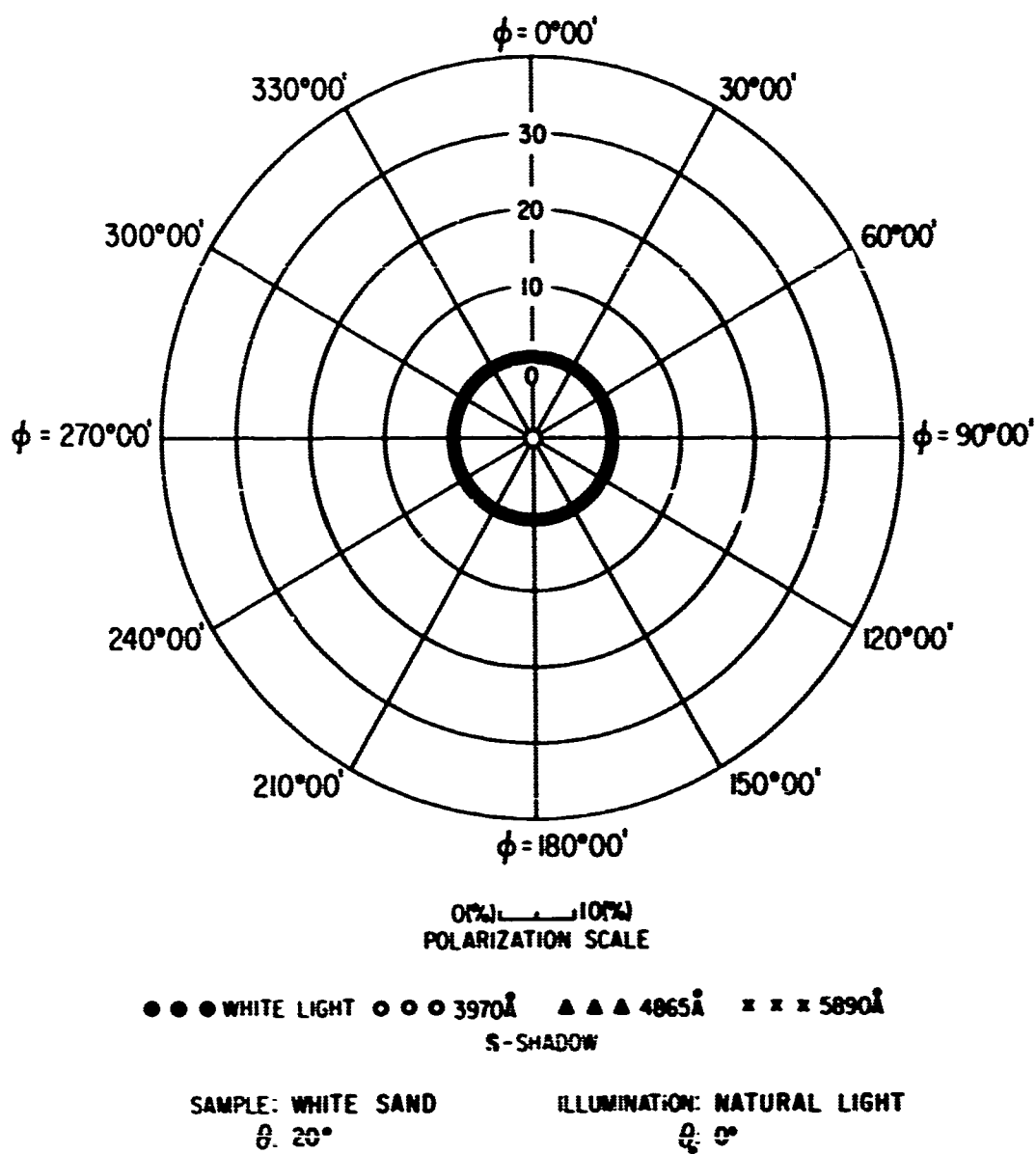
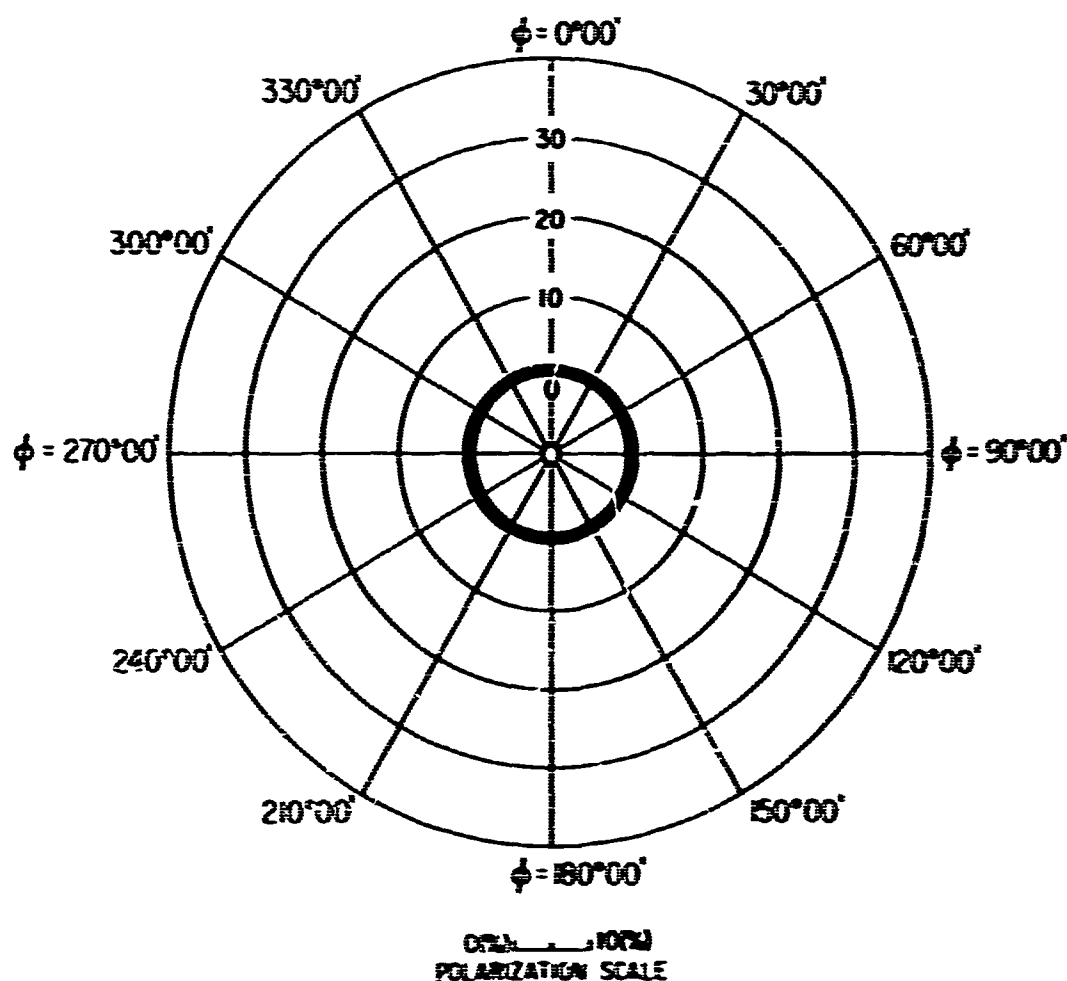


FIG 90. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT



●●● WHITE LIGHT ○○○ 3370Å ▲▲▲ 4865Å ××× 5890Å
 S-SHADOW

SAMPLE: WHITE SAND
 θ 30°

ILLUMINATION: NATURAL LIGHT
 ϕ 0°

FIG 91. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

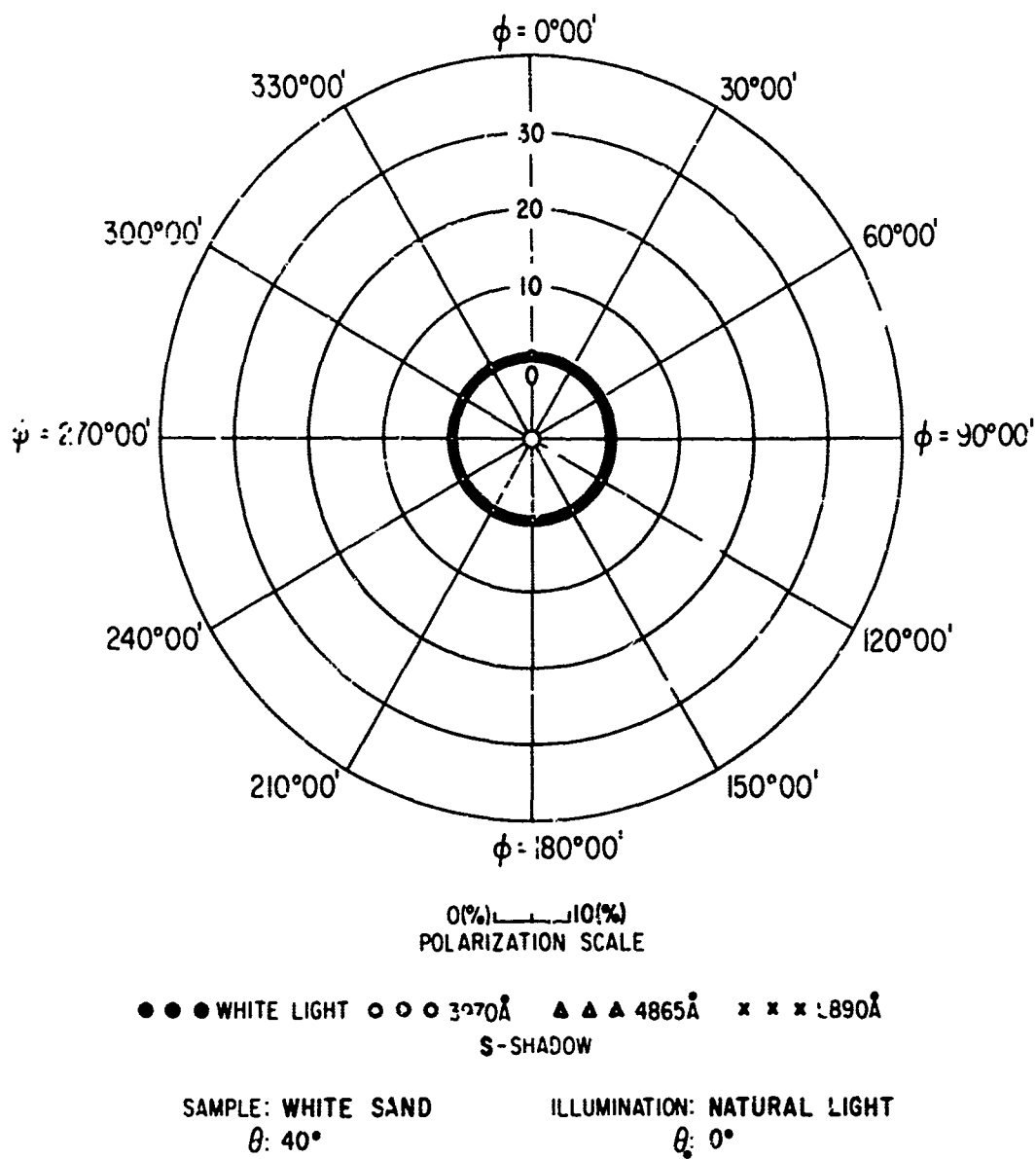
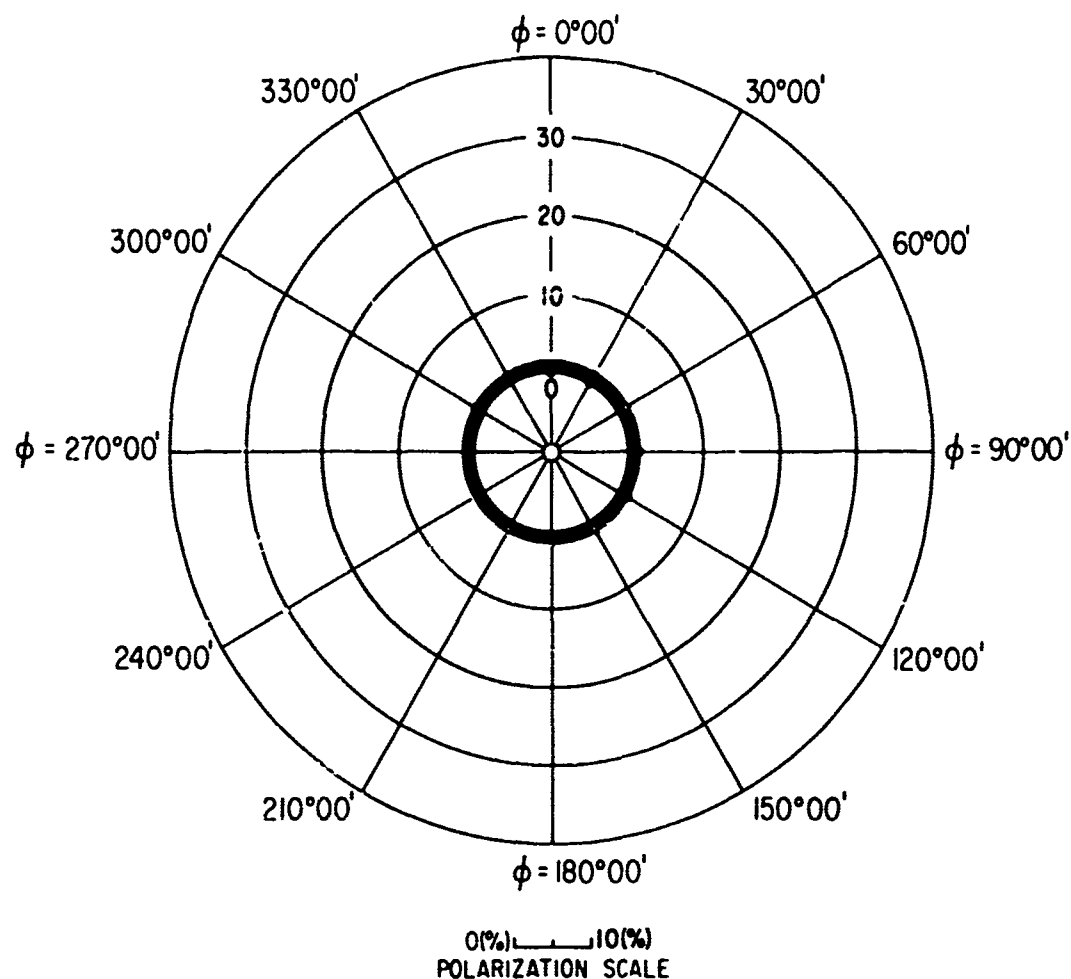


FIG 92. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT



● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
S-SHADOW

SAMPLE: WHITE SAND
 θ : 50°

ILLUMINATION: NATURAL LIGHT
 θ : 0°

FIG 93. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

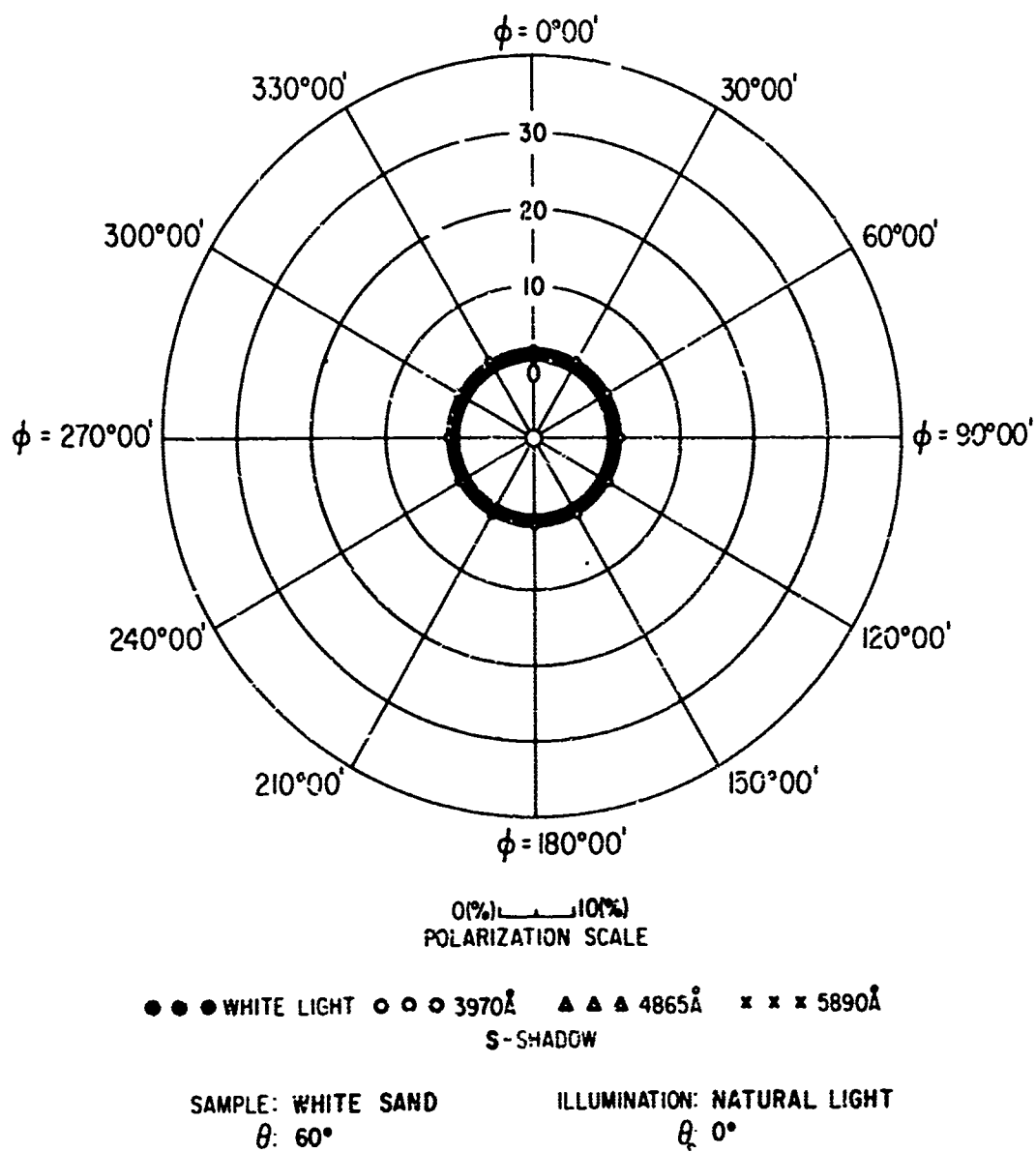


FIG 94. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

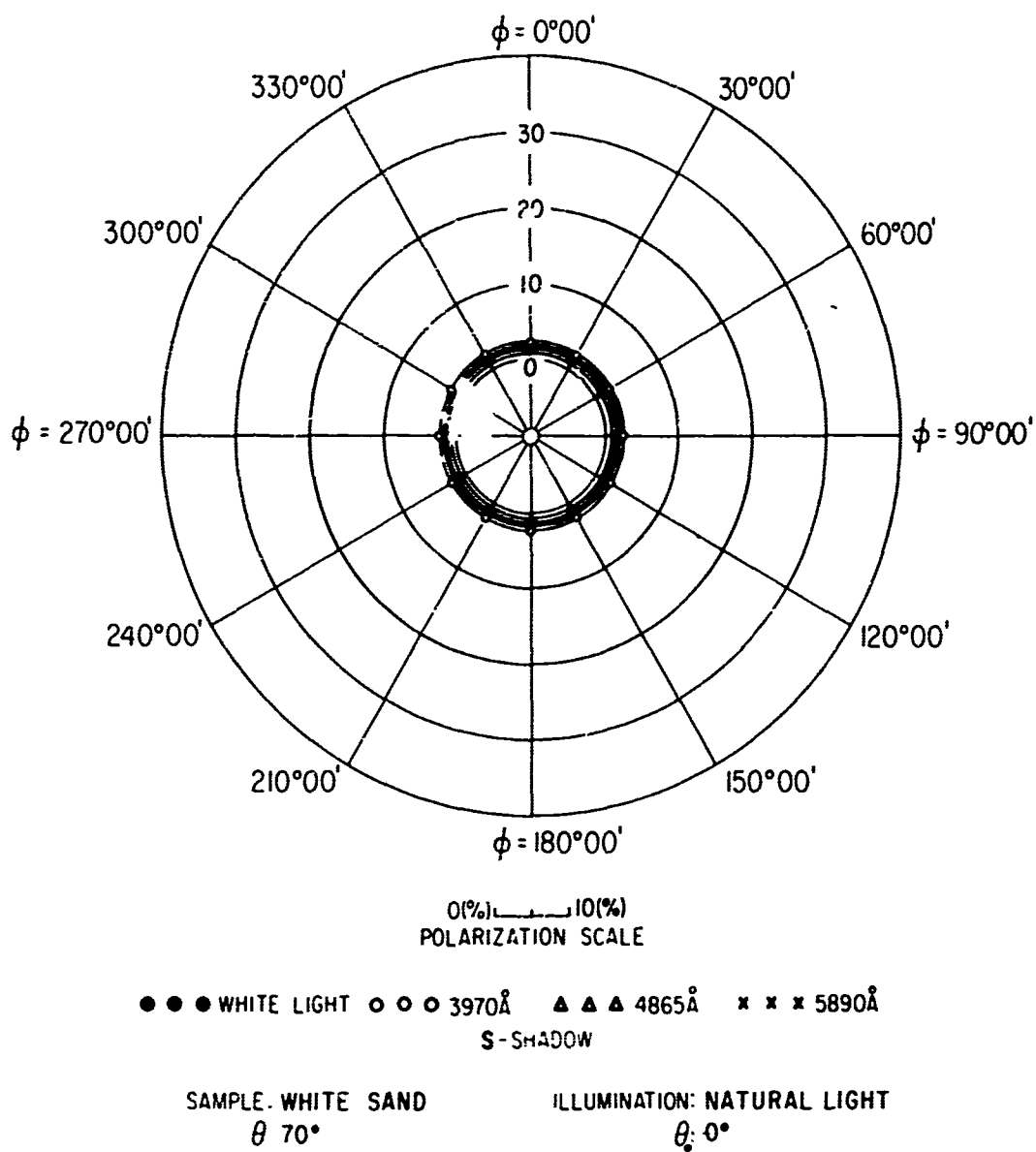


FIG 95. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

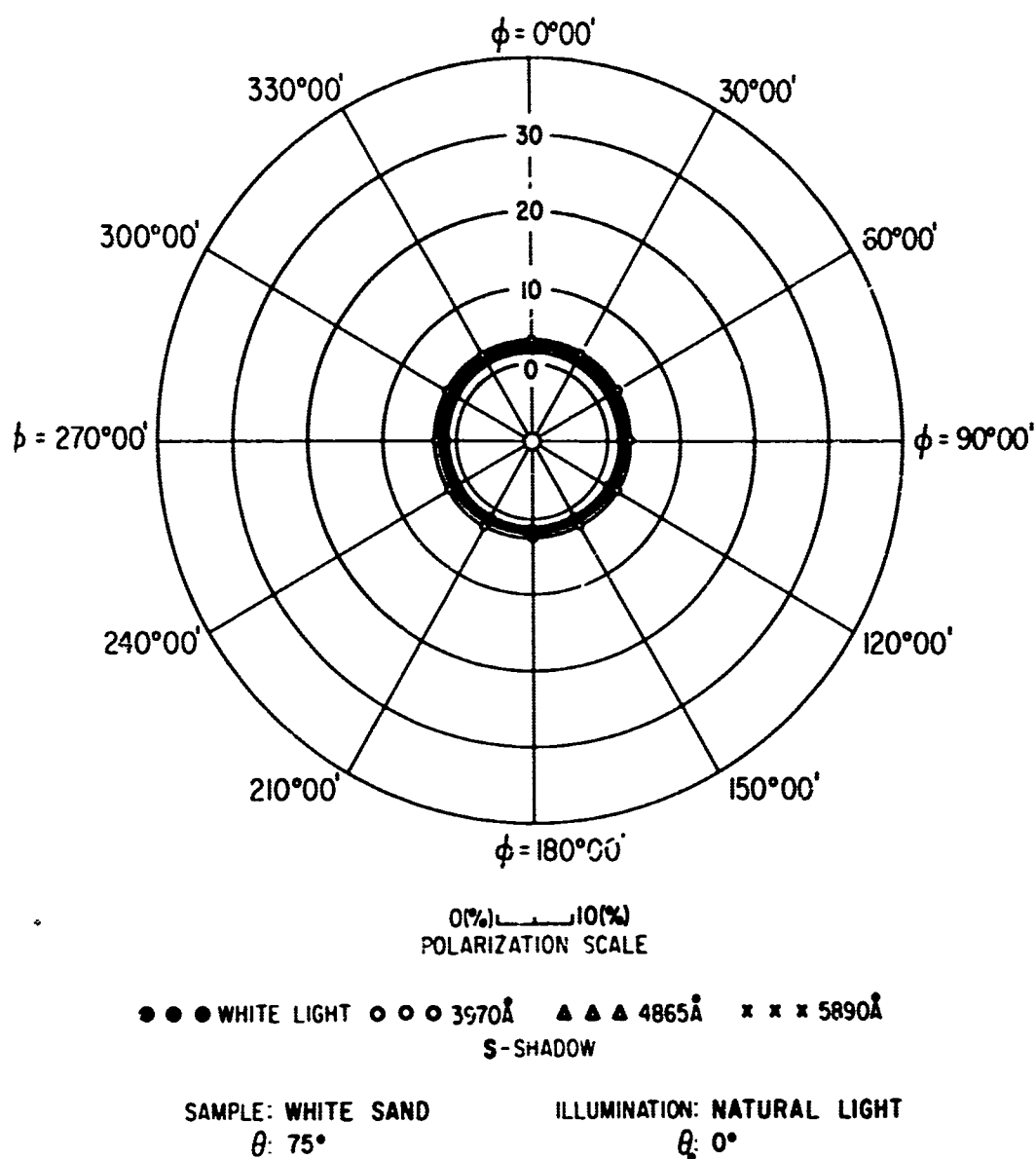


FIG 96. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

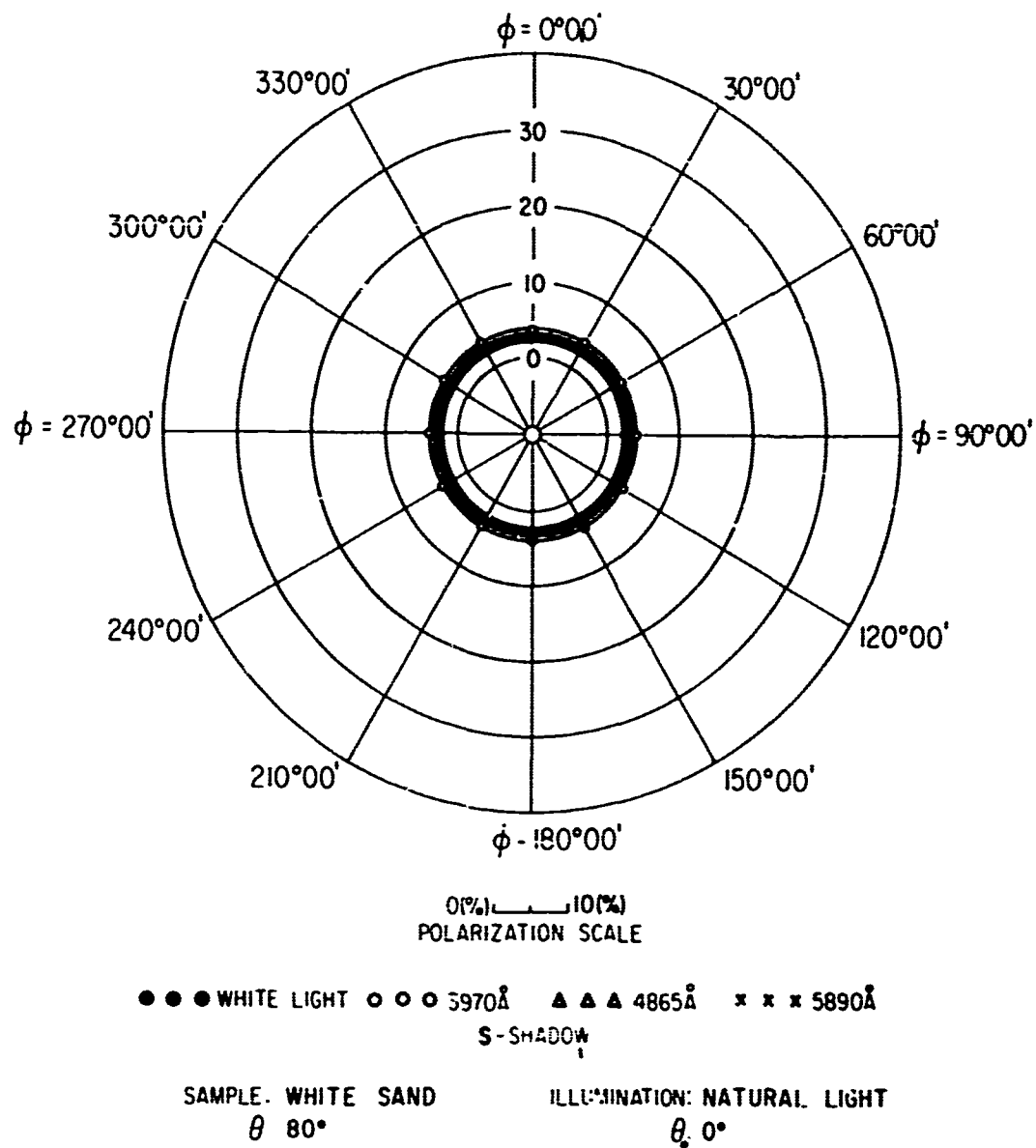


FIG 97. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

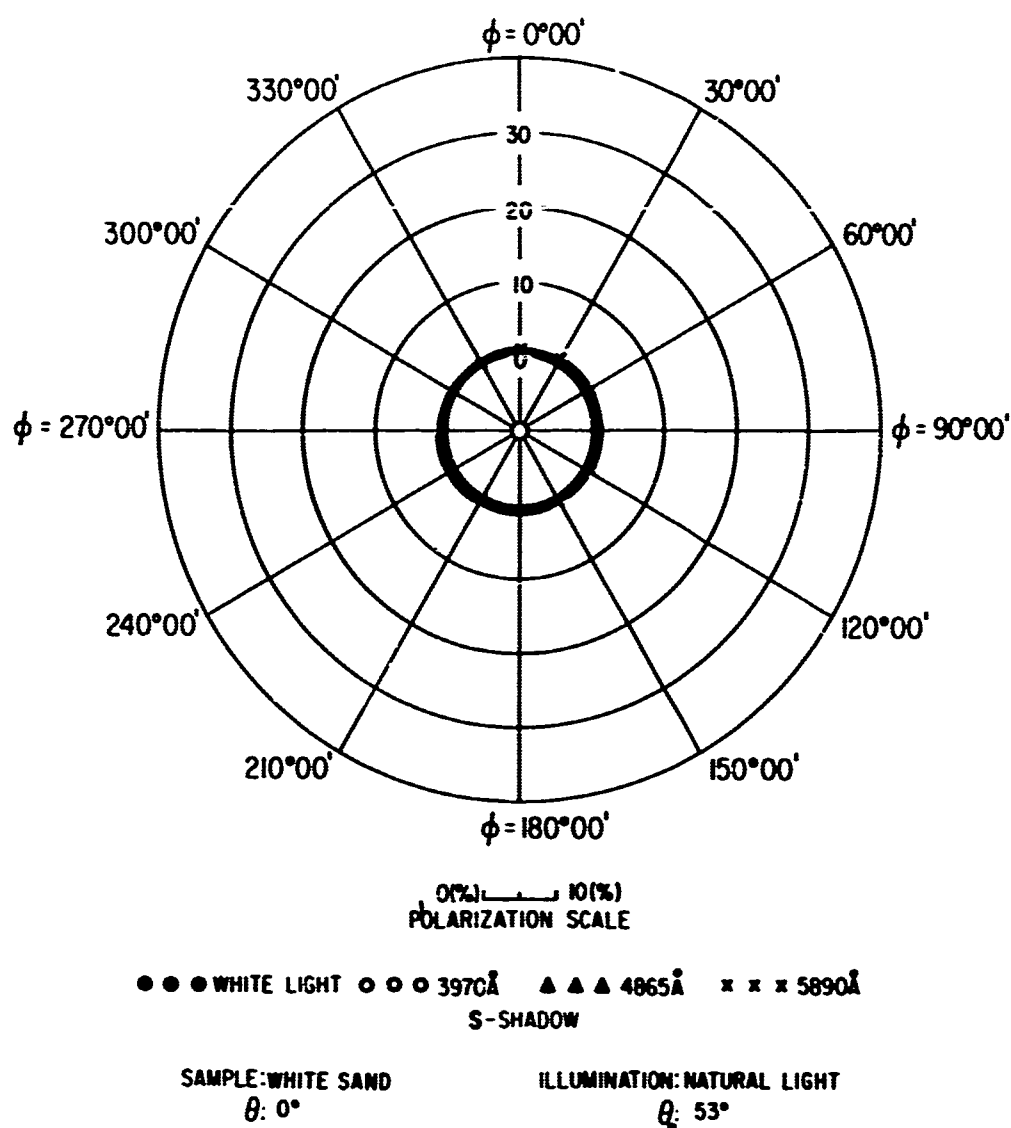
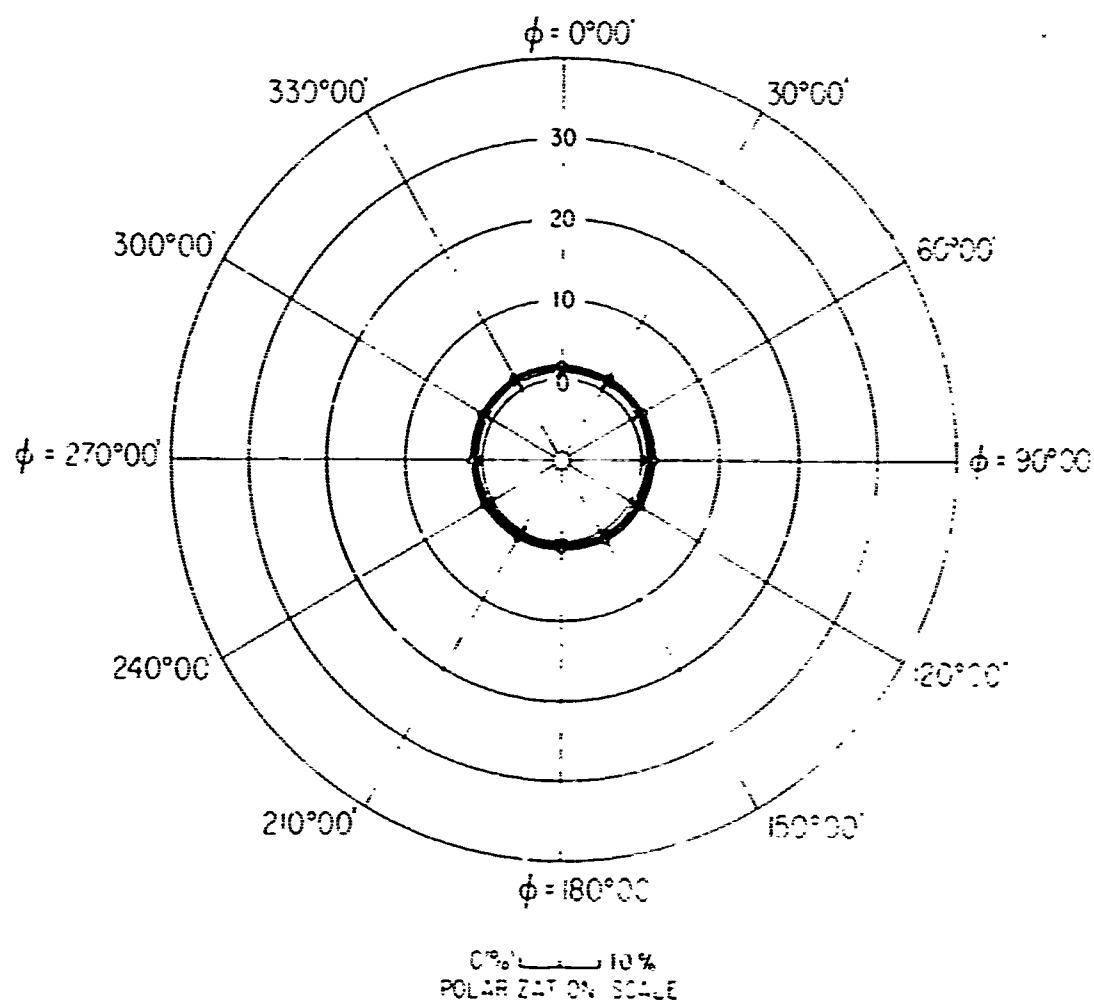


FIG. 98 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT



● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
S-SAND

SAMPLE WHITE SAND
 θ 10°

ILLUMINATION NATURAL LIGHT
 θ 53°

FIG 99 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 1.12 + 0.41 \cos \varphi + 0.12 \cos 2\varphi - 0.13 \cos 3\varphi - 0.07 \cos 4\varphi - 0.02 \cos 5\varphi \\ - 0.03 \cos 6\varphi + 0.07 \sin \varphi + 0.06 \sin 2\varphi + 0.00 \sin 3\varphi + 0.02 \sin 4\varphi - 0.02 \sin 5\varphi$$

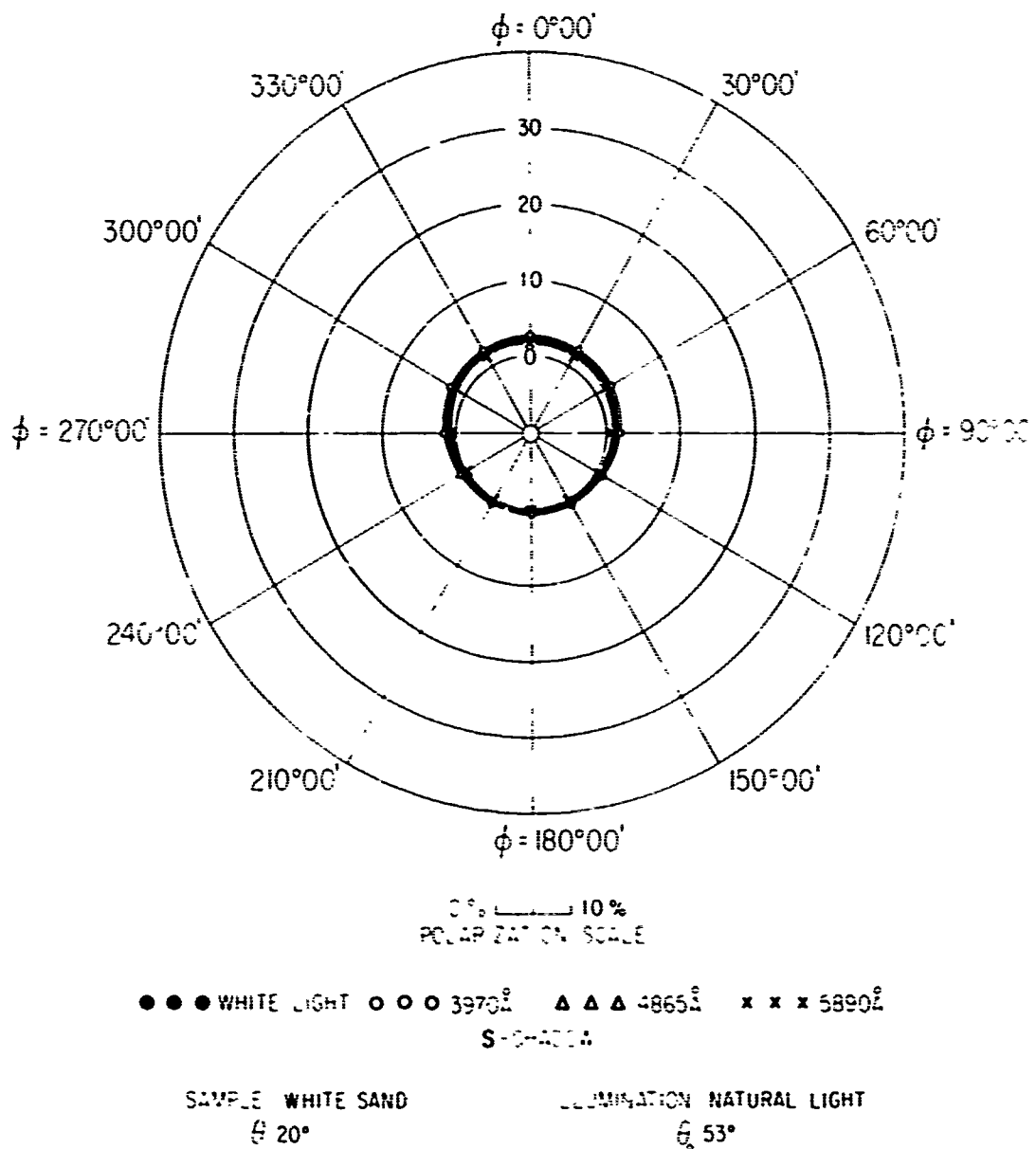


FIG 100 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 1.19 + 1.02 \cos \varphi - 0.12 \cos 2\varphi + 0.07 \cos 3\varphi + 0.12 \cos 4\varphi + 0.01 \cos 5\varphi \\ + 0.08 \cos 6\varphi + 0.02 \sin \varphi - 0.10 \sin 2\varphi - 0.02 \sin 3\varphi - 0.04 \sin 4\varphi - 0.10 \sin 5\varphi$$

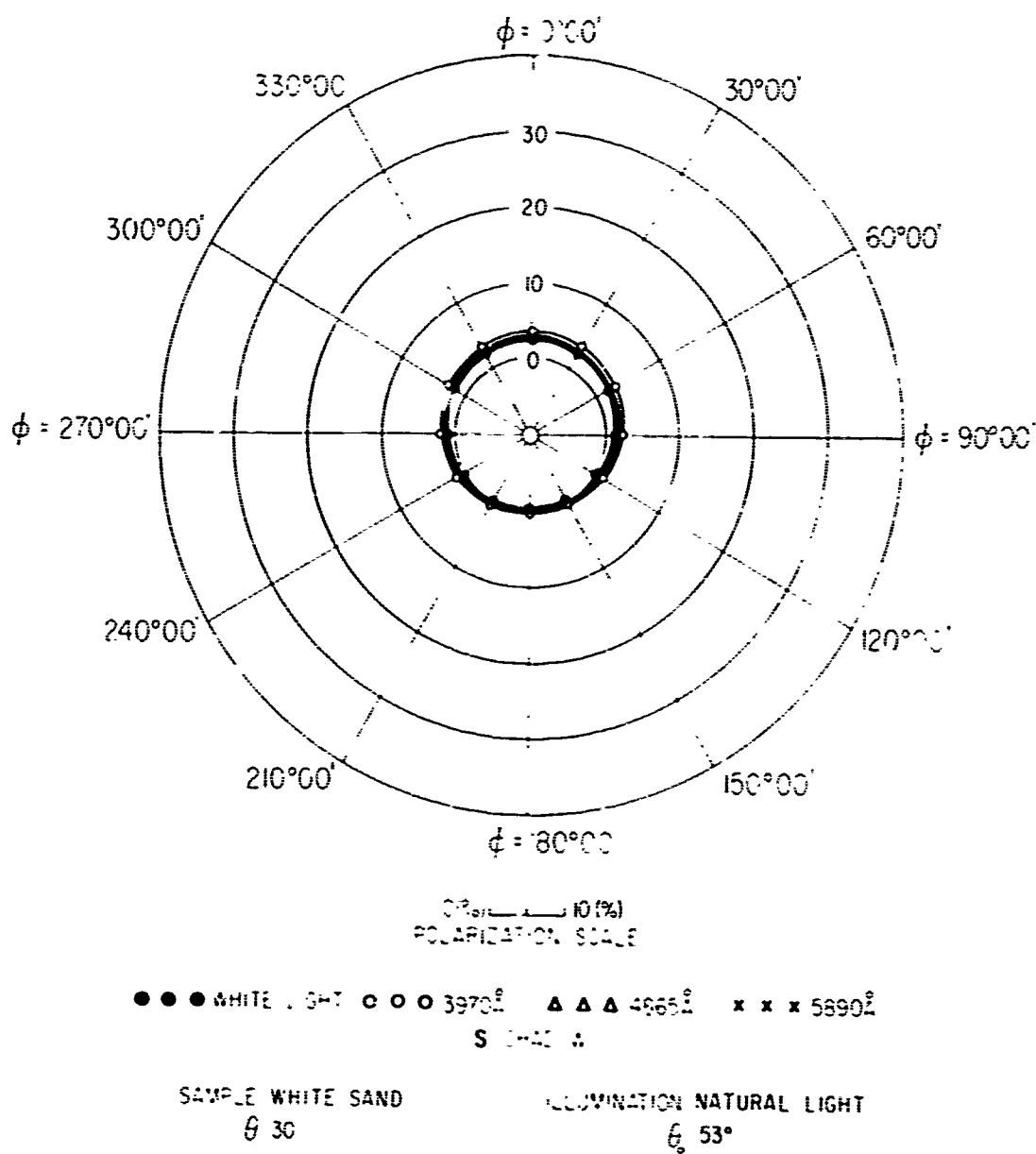


FIG 101 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 1.49 + 1.42 \cos \varphi + 0.02 \cos 2\varphi + 0.10 \cos 3\varphi - 0.02 \cos 4\varphi - 0.02 \cos 5\varphi \\
 & + 0.02 \cos 6\varphi - 0.01 \sin \varphi - 0.06 \sin 2\varphi - 0.02 \sin 3\varphi + 0.00 \sin 4\varphi + 0.04 \sin 5\varphi
 \end{aligned}$$

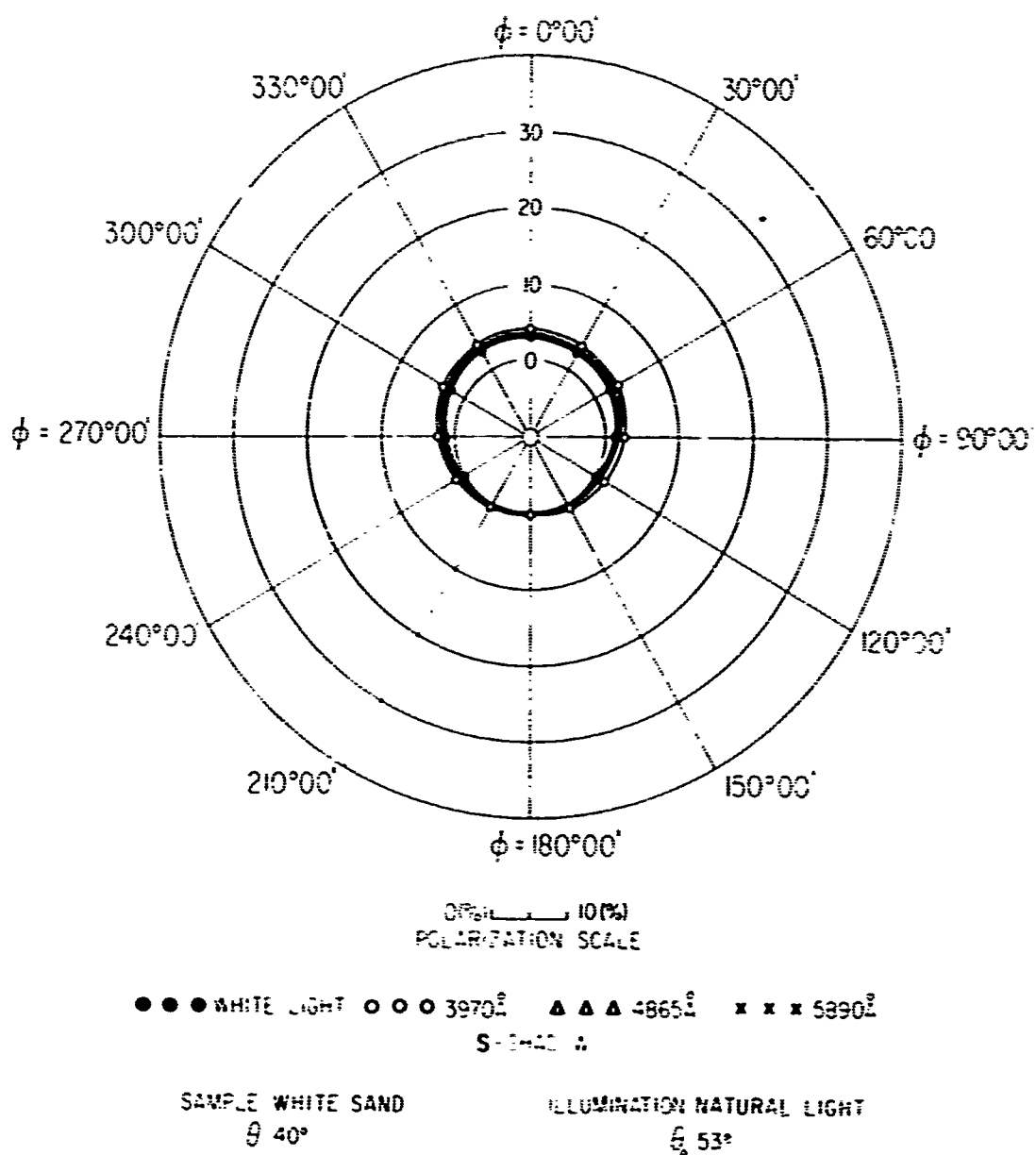


FIG 102 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 1.95 + 1.82 \cos \varphi + 0.05 \cos 2\varphi + 0.08 \cos 3\varphi + 0.00 \cos 4\varphi - 0.11 \cos 5\varphi \\
 & + 0.00 \cos 6\varphi + 0.12 \sin \varphi - 0.03 \sin 2\varphi - 0.02 \sin 3\varphi - 0.06 \sin 4\varphi - 0.06 \sin 5\varphi
 \end{aligned}$$

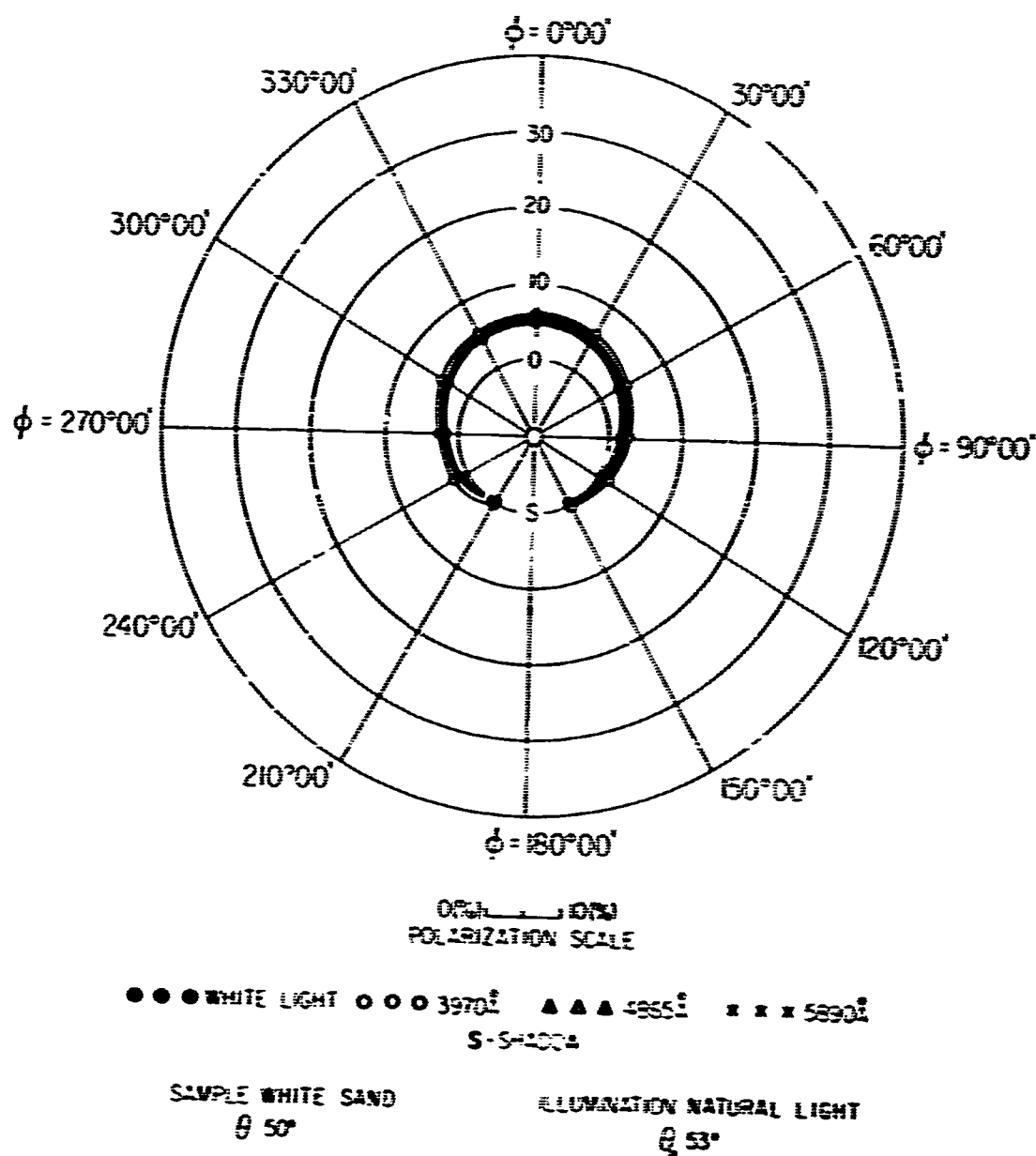


FIG 103 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 2.48 + 2.25 \cos \phi + 0.14 \cos 2\phi + 0.23 \cos 3\phi - 0.62 \cos 4\phi + 0.06 \cos 5\phi \\ - 0.08 \cos 6\phi + 0.16 \sin \phi + 0.04 \sin 2\phi + 0.05 \sin 3\phi + 0.01 \sin 4\phi - 0.16 \sin 5\phi$$

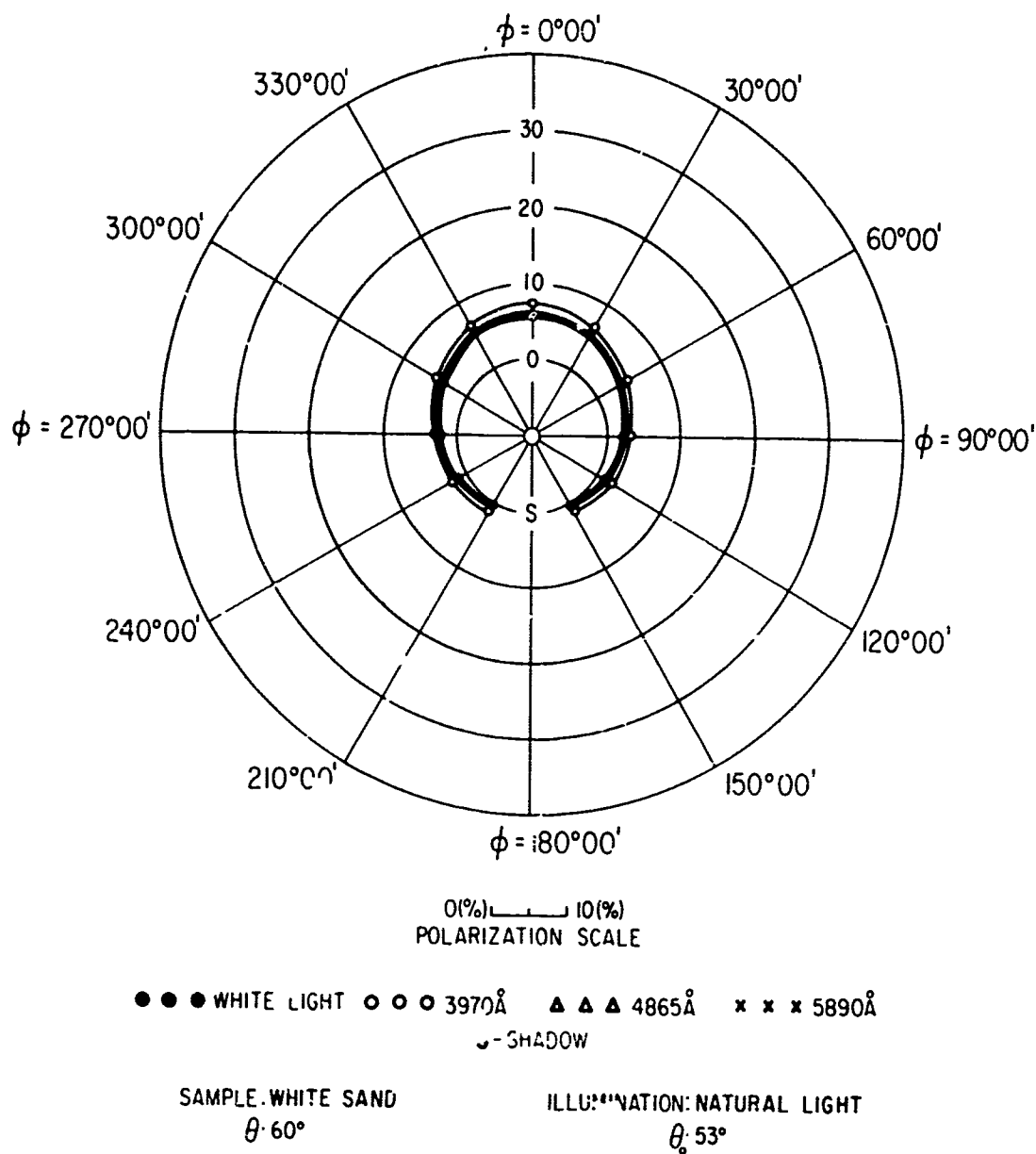


FIG 104 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 3.19 + 2.83 \cos \phi + 0.12 \cos 2\phi + 0.27 \cos 3\phi - 0.07 \cos 4\phi + 0.15 \cos 5\phi \\
 & + 0.02 \cos 6\phi + 0.30 \sin \phi + 0.12 \sin 2\phi - 0.02 \sin 3\phi - 0.03 \sin 4\phi - 0.03 \sin 5\phi
 \end{aligned}$$

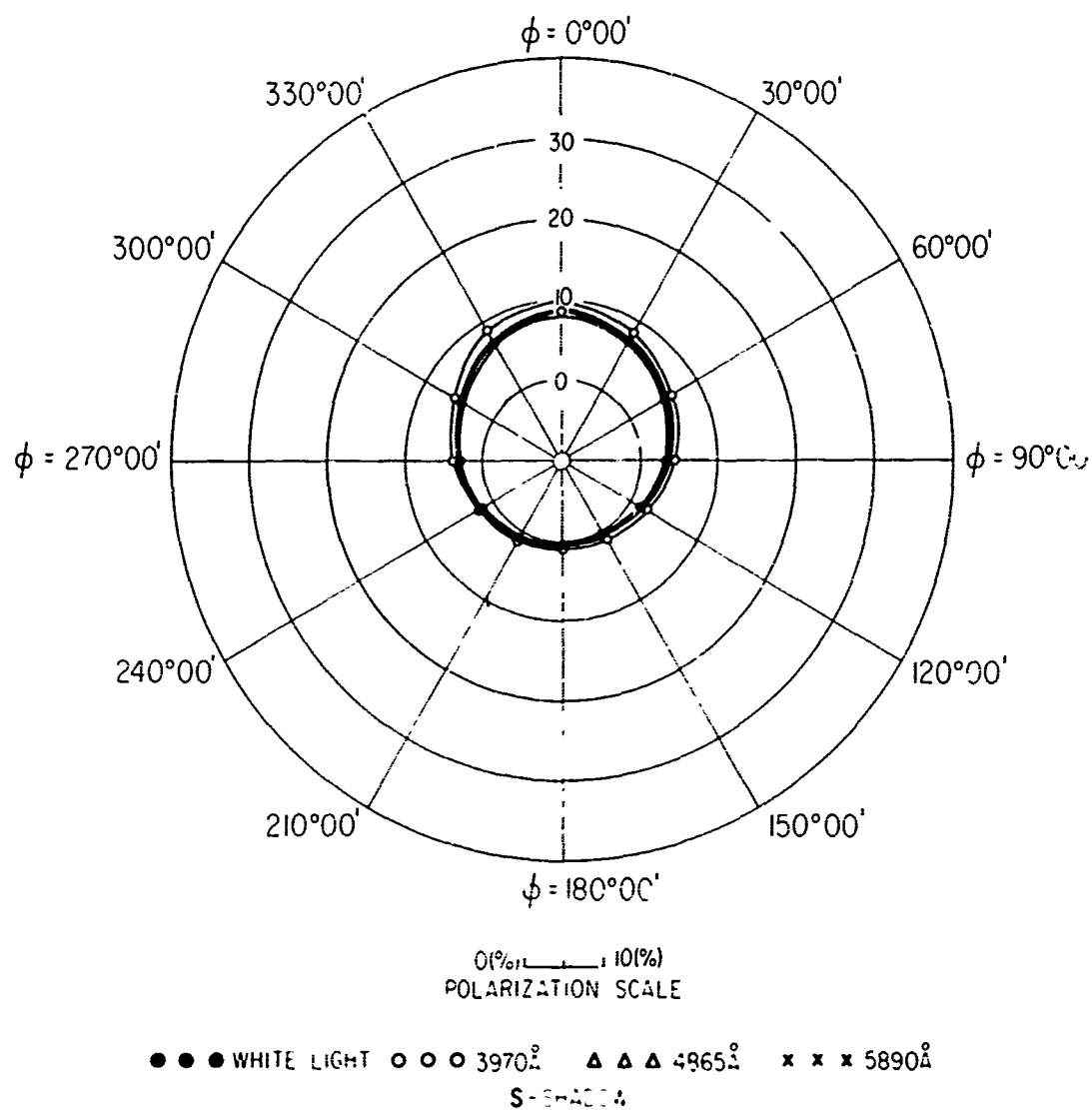


FIG 105 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 3.98 + 3.57 \cos \varphi + 0.54 \cos 2\varphi + 0.32 \cos 3\varphi + 0.14 \cos 4\varphi + 0.05 \cos 5\varphi \\
 & + 0.27 \cos 6\varphi + 0.08 \sin \varphi + 0.10 \sin 2\varphi + 0.08 \sin 3\varphi + 0.01 \sin 4\varphi + 0.05 \sin 5\varphi
 \end{aligned}$$

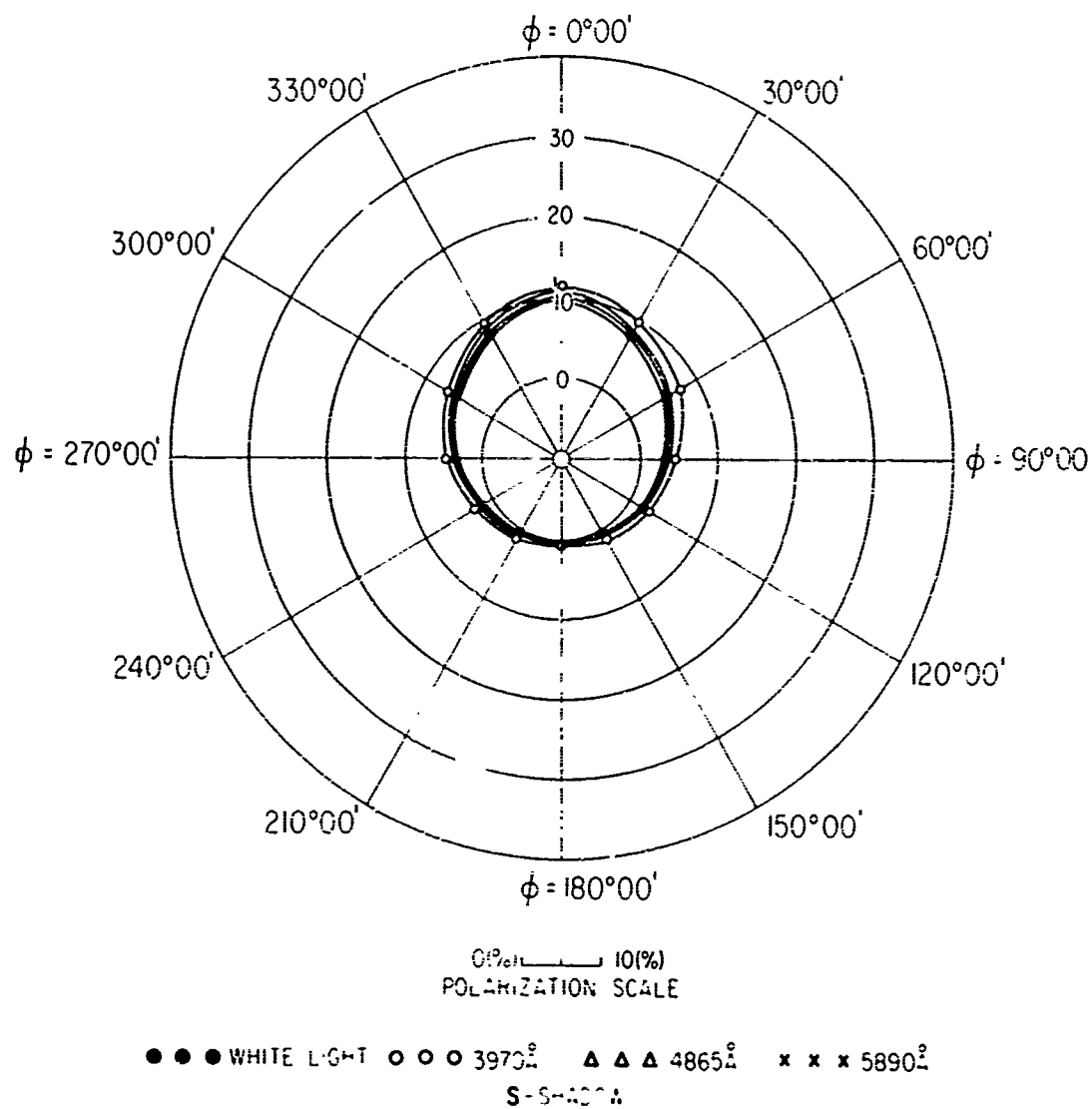
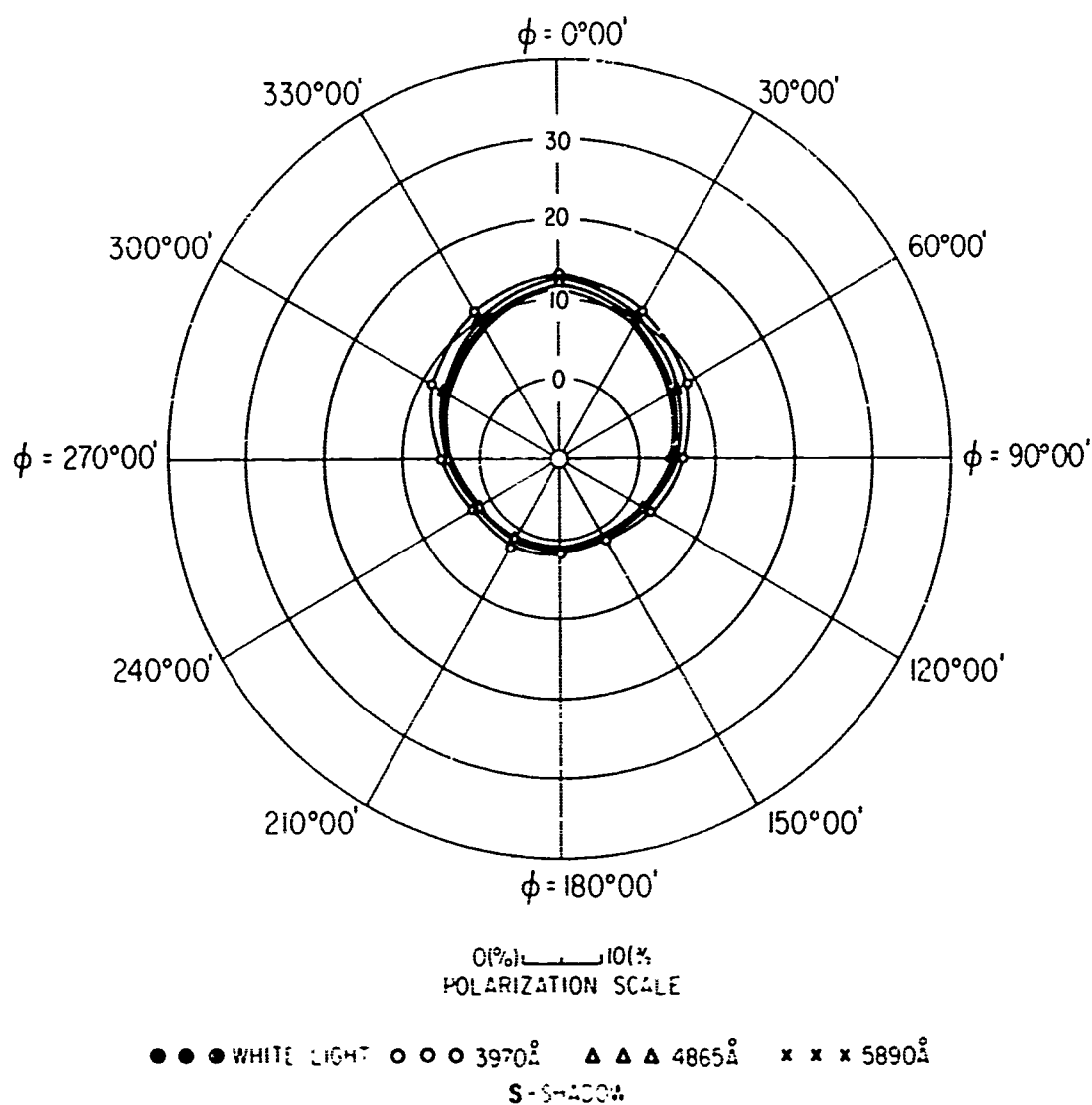


FIG 106 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 4.54 + 4.12 \cos \phi + 0.73 \cos 2\phi + 0.45 \cos 3\phi + 0.08 \cos 4\phi + 0.22 \cos 5\phi \\
 & + 0.08 \cos 6\phi + 0.41 \sin \phi + 0.12 \sin 2\phi - 0.07 \sin 3\phi + 0.03 \sin 4\phi + 0.27 \sin 5\phi
 \end{aligned}$$



SAMPLE WHITE SAND
 θ 80°

ILLUMINATION NATURAL LIGHT
 θ_i 53°

FIG 107 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 5.21 + 4.31 \cos \varphi + 0.95 \cos 2\varphi + 0.52 \cos 3\varphi + 0.22 \cos 4\varphi + 0.32 \cos 5\varphi \\ + 0.35 \cos 6\varphi + 0.18 \sin \varphi + 0.00 \sin 2\varphi - 0.03 \sin 3\varphi - 0.06 \sin 4\varphi - 0.11 \sin 5\varphi$$

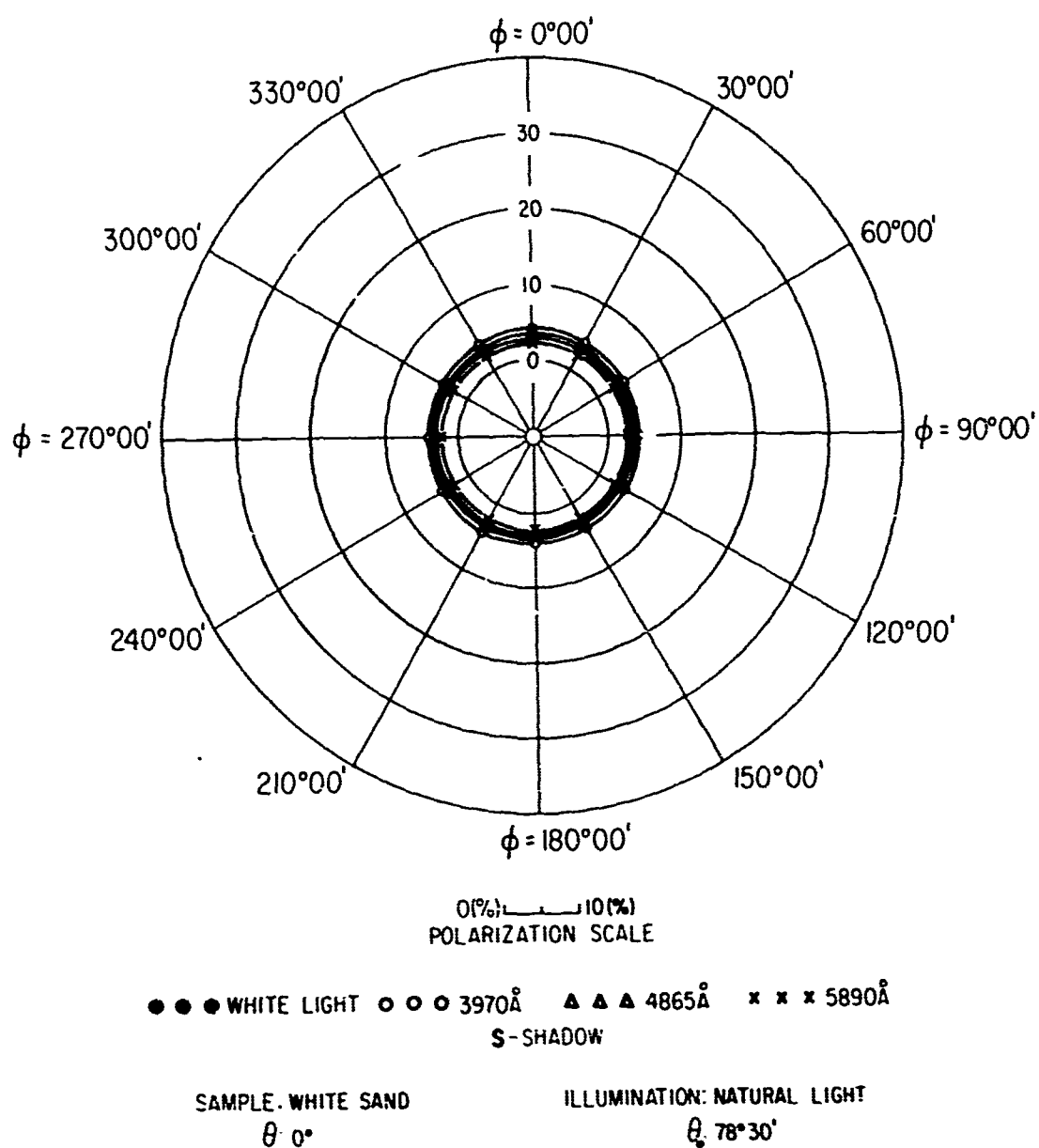
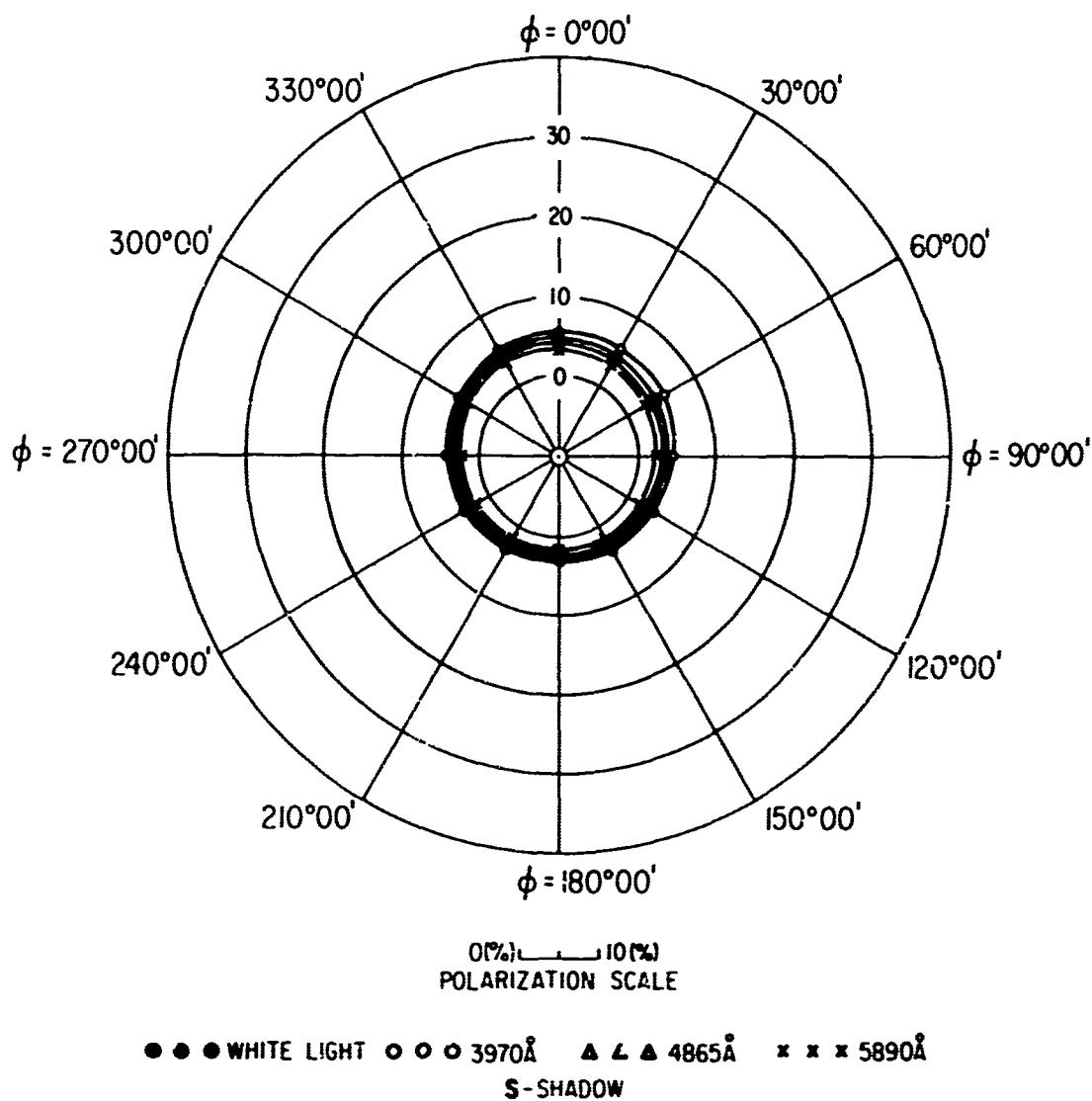


FIG 108 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT



SAMPLE. WHITE SAND
 $\theta: 10^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 78^\circ 30'$

FIG 109 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 3.63 + 1.34 \cos \varphi + 0.20 \cos 2\varphi + 0.07 \cos 3\varphi - 0.08 \cos 4\varphi + 0.13 \cos 5\varphi \\ + 0.00 \cos 6\varphi - 0.02 \sin \varphi - 0.02 \sin 2\varphi + 0.03 \sin 3\varphi + 0.06 \sin 4\varphi + 0.00 \sin 5\varphi$$

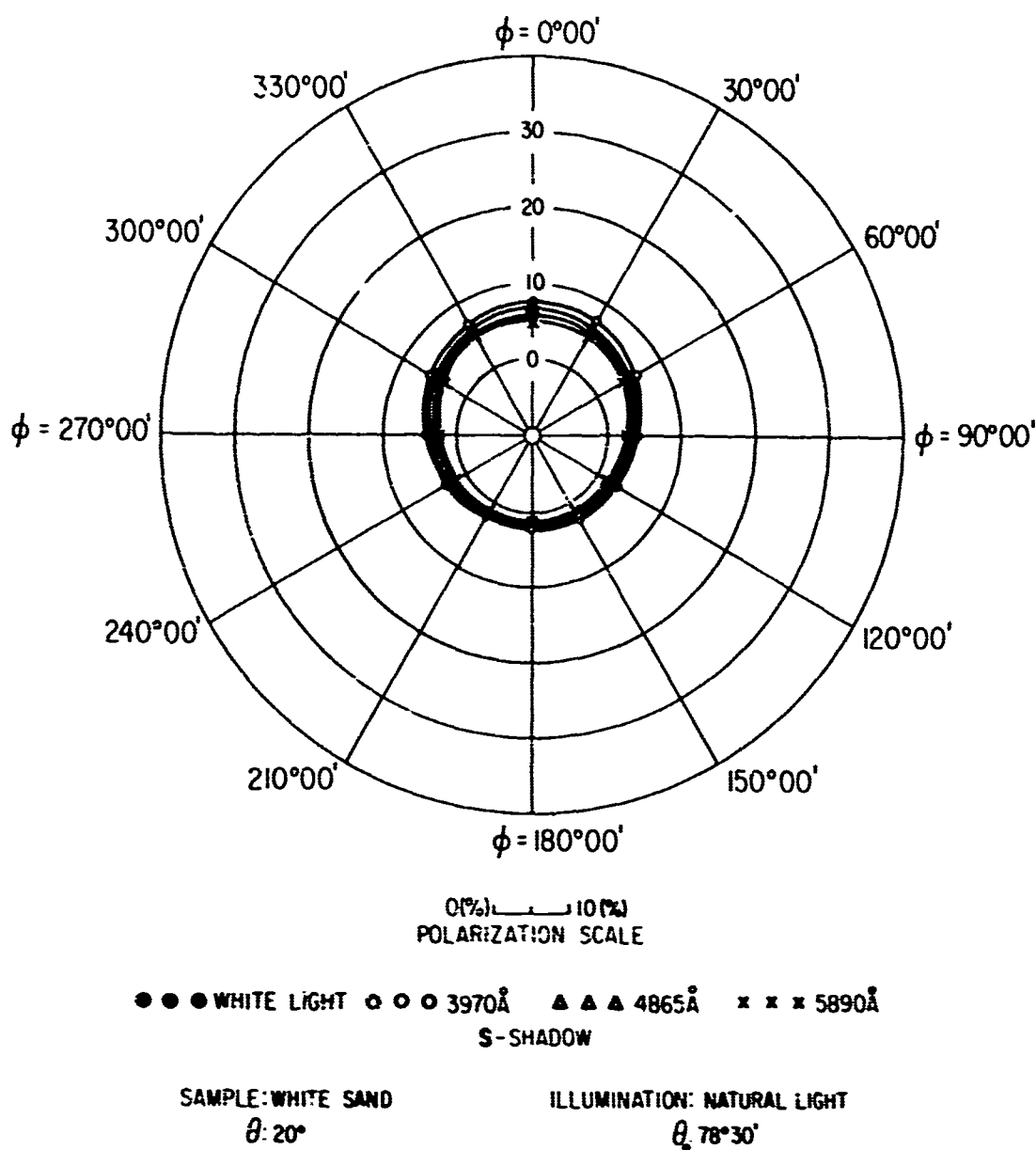


FIG. 110 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 3.82 + 2.44 \cos \phi + 0.36 \cos 2\phi + 0.15 \cos 3\phi + 0.02 \cos 4\phi + 0.01 \cos 5\phi \\
 & - 0.02 \cos 6\phi - 0.10 \sin \phi - 0.10 \sin 2\phi + 0.03 \sin 3\phi - 0.10 \sin 4\phi + 0.04 \sin 5\phi
 \end{aligned}$$

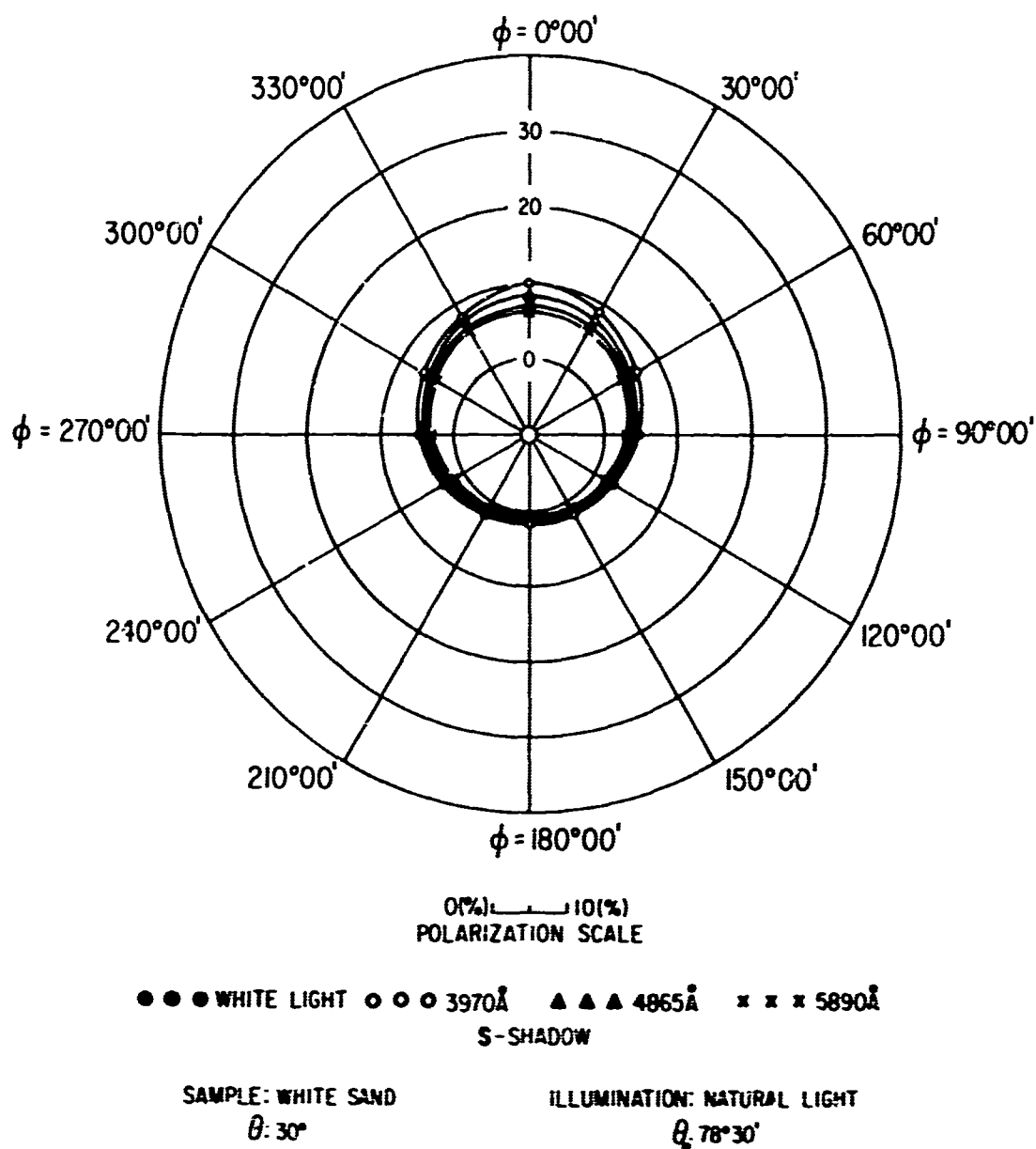


FIG. III POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 4.17 + 3.66 \cos \phi + 0.46 \cos 2\phi + 0.23 \cos 3\phi + 0.11 \cos 4\phi + 0.11 \cos 5\phi \\
 & + 0.13 \cos 6\phi - 0.02 \sin \phi + 0.10 \sin 2\phi - 0.03 \sin 3\phi + 0.07 \sin 4\phi - 0.07 \sin 5\phi
 \end{aligned}$$

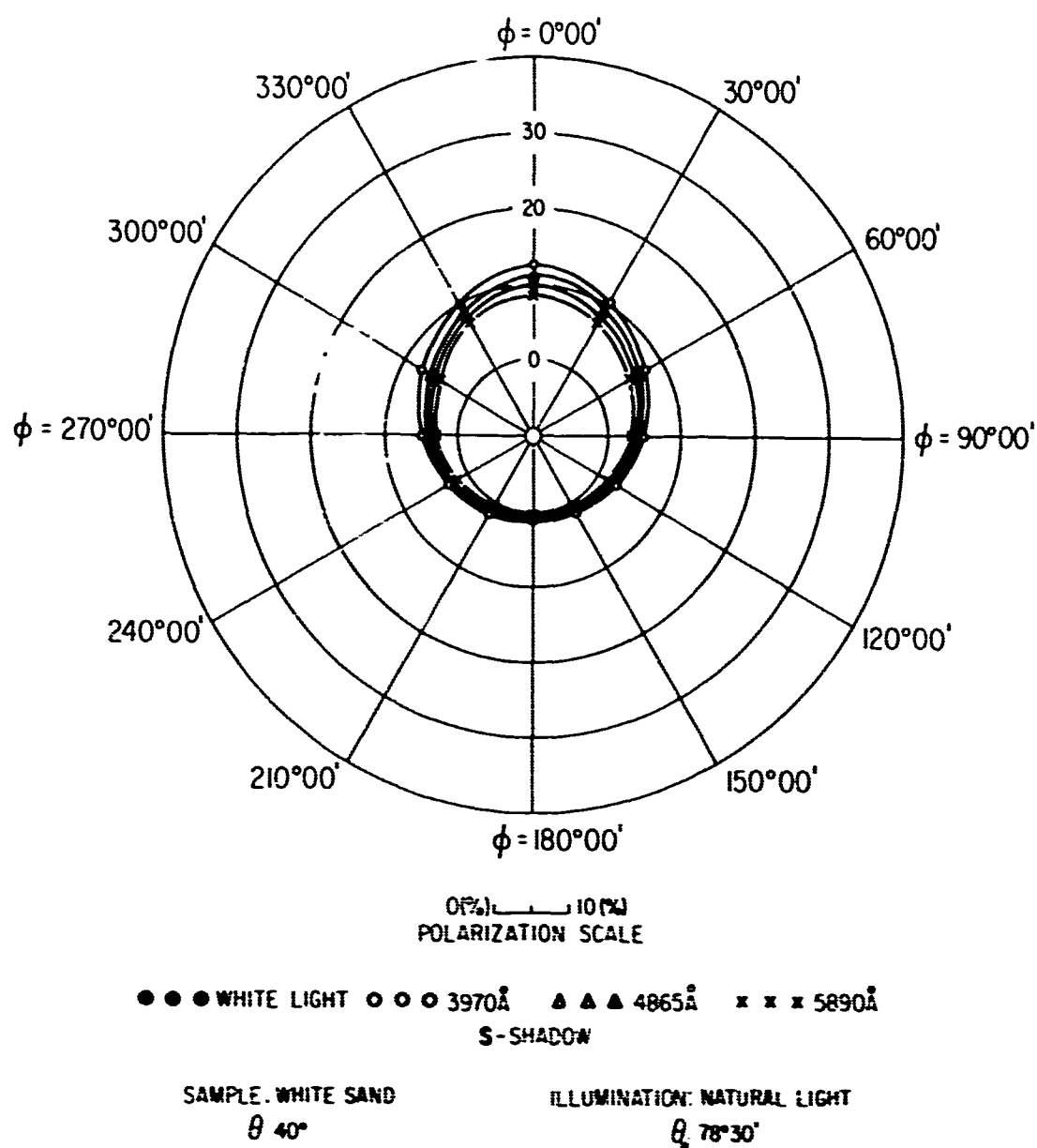


FIG 112 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 4.78 + 4.72 \cos \phi + 0.83 \cos 2\phi + 0.45 \cos 3\phi + 0.17 \cos 4\phi + 0.28 \cos 5\phi \\
 & + 0.13 \cos 6\phi + 0.12 \sin \phi + 0.02 \sin 2\phi - 0.02 \sin 3\phi + 0.68 \sin 4\phi + 0.01 \sin 5\phi
 \end{aligned}$$

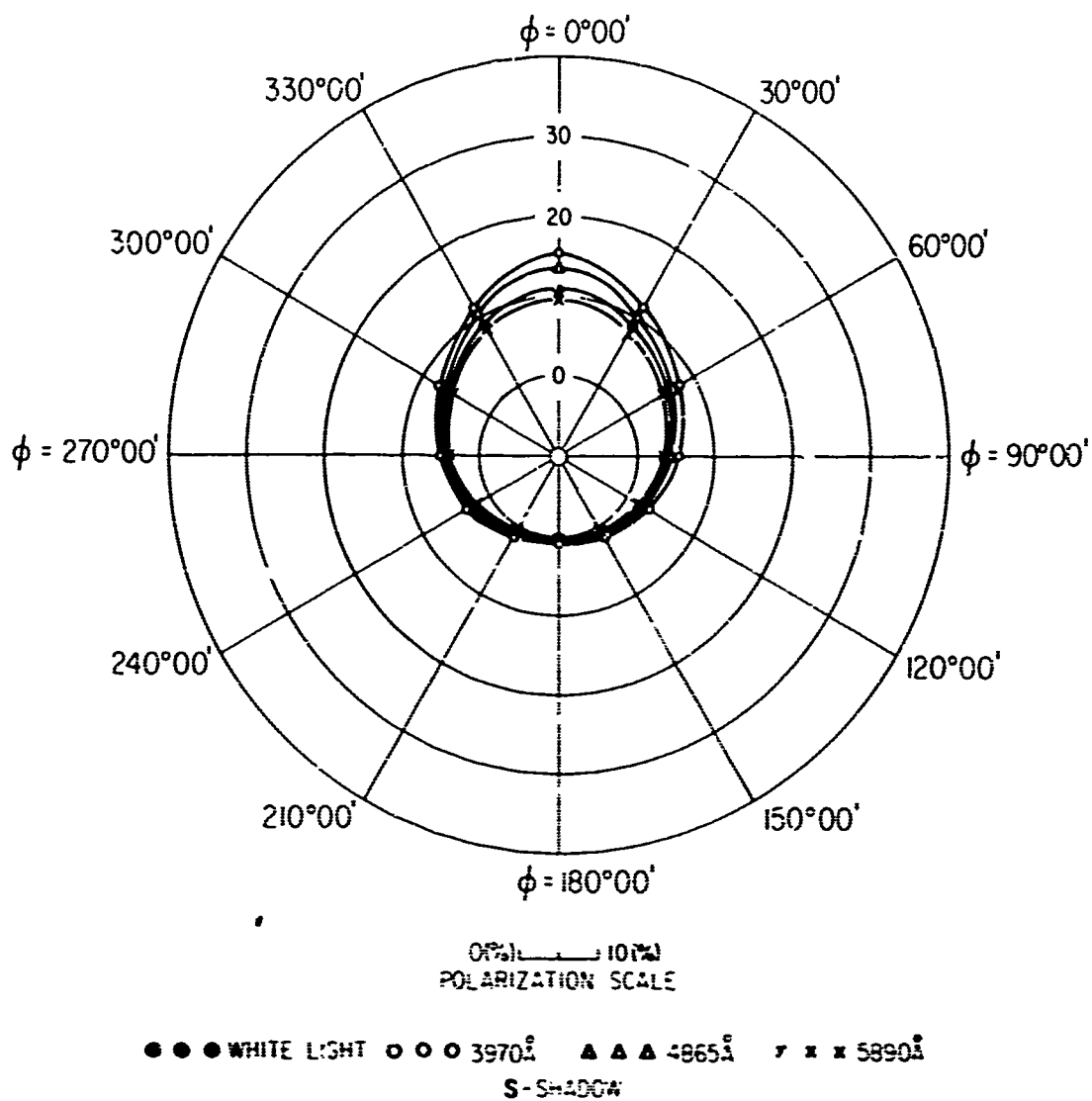


FIG II3 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.32 + 5.69 \cos \phi + 1.08 \cos 2\phi + 0.78 \cos 3\phi + 0.51 \cos 4\phi + 0.43 \cos 5\phi \\
 & + 0.20 \cos 6\phi + 0.02 \sin \phi - 0.01 \sin 2\phi - 0.05 \sin 3\phi + 0.02 \sin 4\phi - 0.02 \sin 5\phi
 \end{aligned}$$

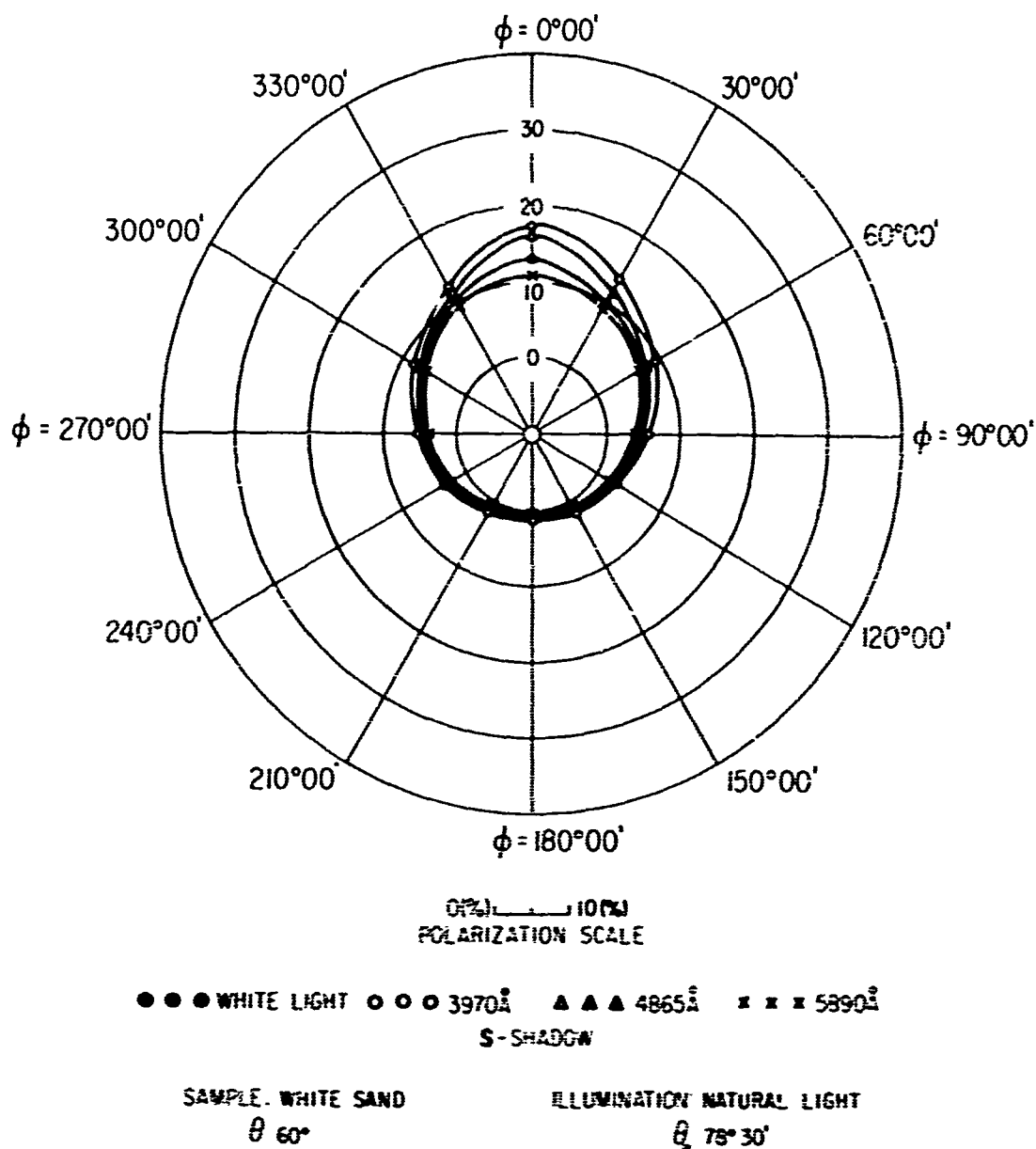


FIG 114 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.75 + 6.32 \cos \phi + 1.68 \cos 2\phi + 1.13 \cos 3\phi + 0.68 \cos 4\phi + 0.49 \cos 5\phi \\
 & + 0.30 \cos 6\phi - 0.04 \sin \phi - 0.24 \sin 2\phi + 0.03 \sin 3\phi + 0.13 \sin 4\phi + 0.28 \sin 5\phi
 \end{aligned}$$

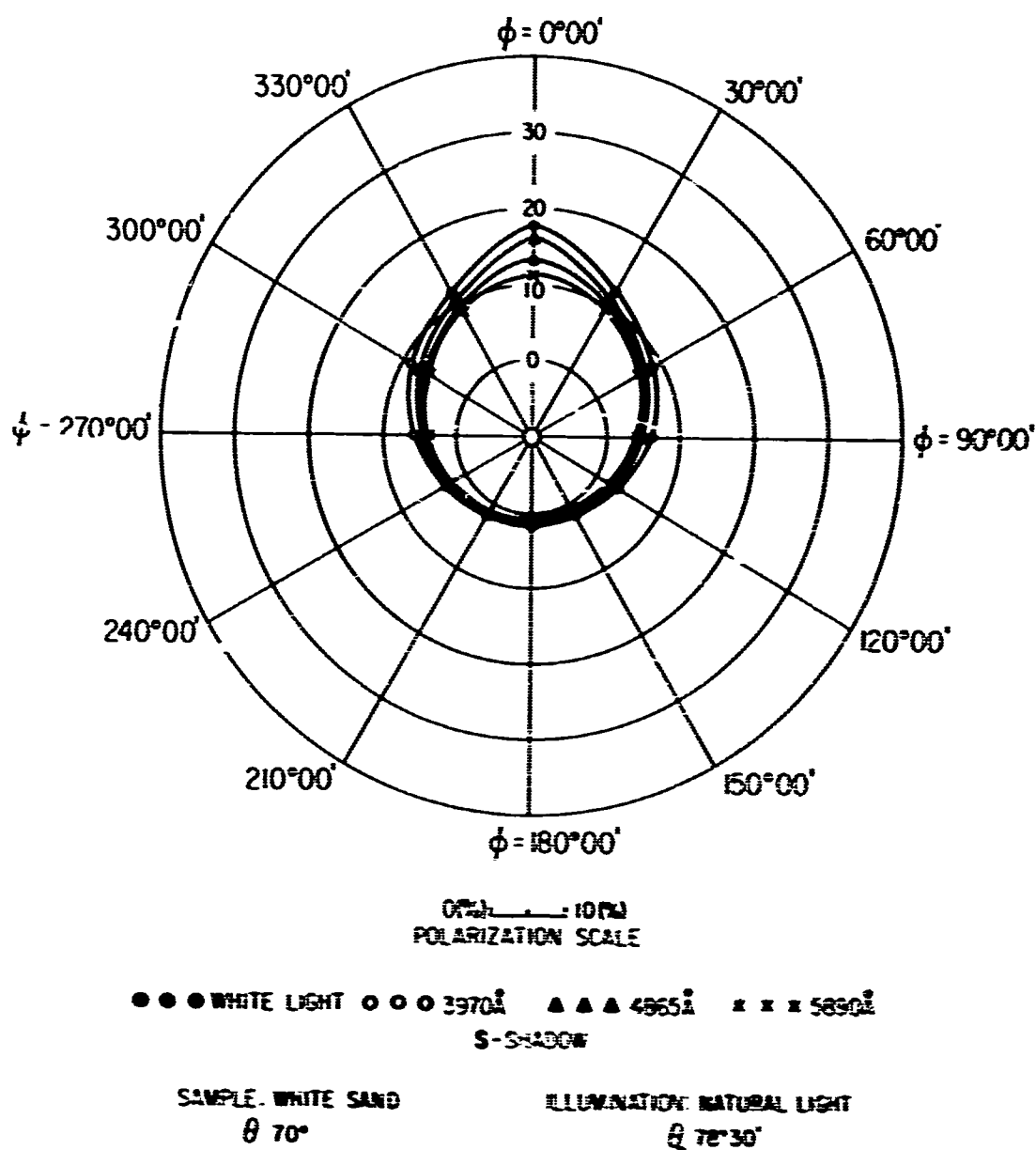


FIG II5 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.66 + 6.06 \cos \phi + 1.80 \cos 2\phi + 0.95 \cos 3\phi + 0.42 \cos 4\phi + 0.89 \cos 5\phi \\
 & + 1.45 \cos 6\phi + 0.48 \sin \phi - 0.06 \sin 2\phi - 0.33 \sin 3\phi - 0.20 \sin 4\phi + 0.04 \sin 5\phi
 \end{aligned}$$

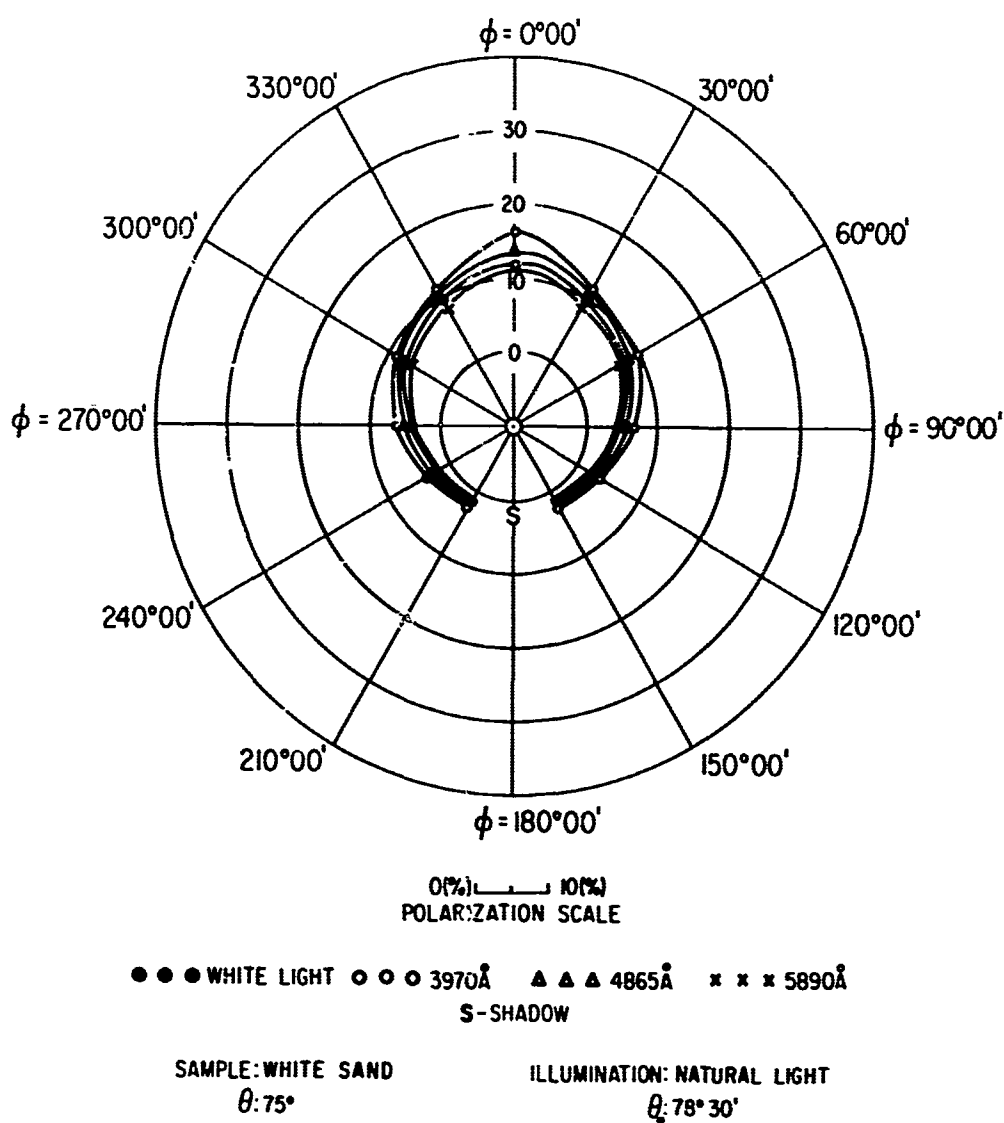
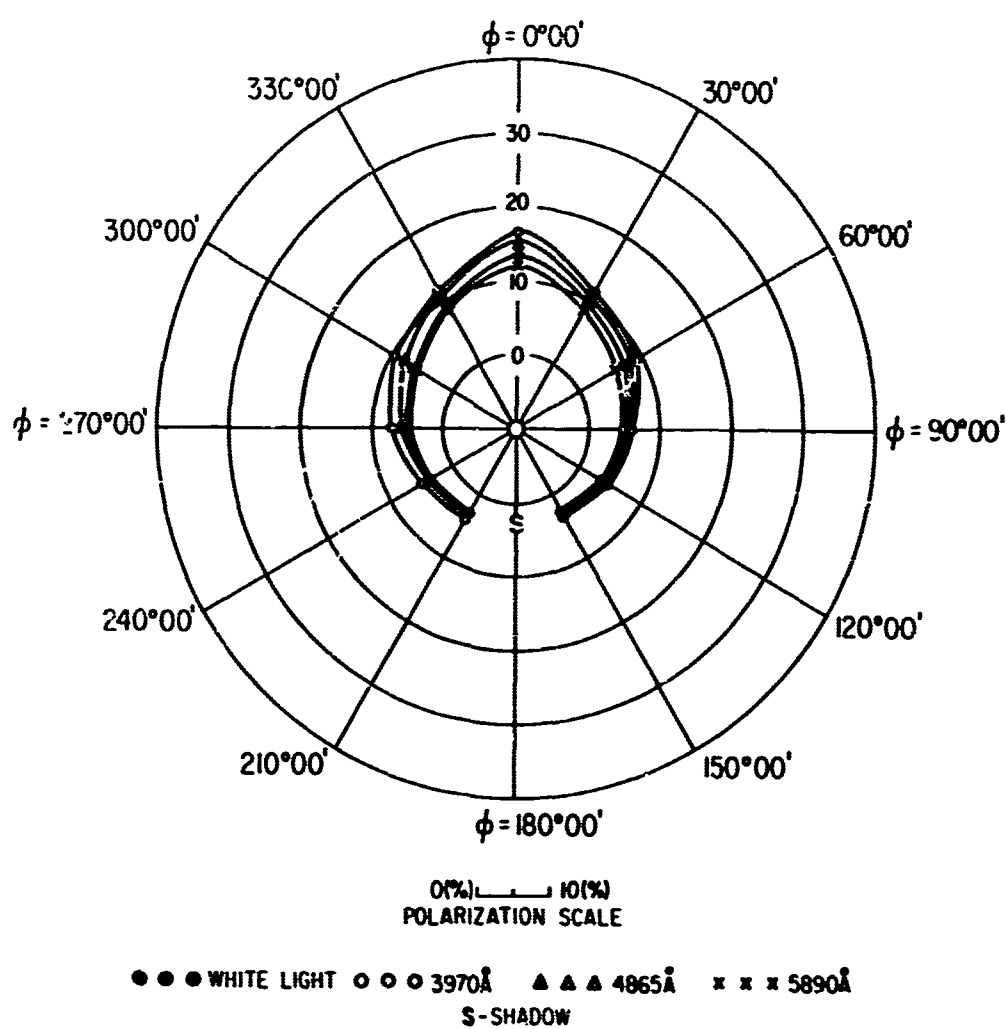


FIG. II6 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.47 + 6.12 \cos \varphi + 1.24 \cos 2\varphi + 1.12 \cos 3\varphi + 0.56 \cos 4\varphi + 0.72 \cos 5\varphi \\
 & + 1.38 \cos 6\varphi - 0.22 \sin \varphi + 0.42 \sin 2\varphi - 0.18 \sin 3\varphi - 0.22 \sin 4\varphi + 0.24 \sin 5\varphi
 \end{aligned}$$



SAMPLE: WHITE SAND
 $\theta: 80^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 78^\circ 30'$

FIG. II7 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.47 + 4.97 \cos \phi + 2.02 \cos 2\phi + 0.85 \cos 3\phi + 1.01 \cos 4\phi + 1.13 \cos 5\phi \\
 & + 0.96 \cos 6\phi - 1.26 \sin \phi - 0.96 \sin 2\phi - 0.05 \sin 3\phi + 0.19 \sin 4\phi + 0.01 \sin 5\phi
 \end{aligned}$$

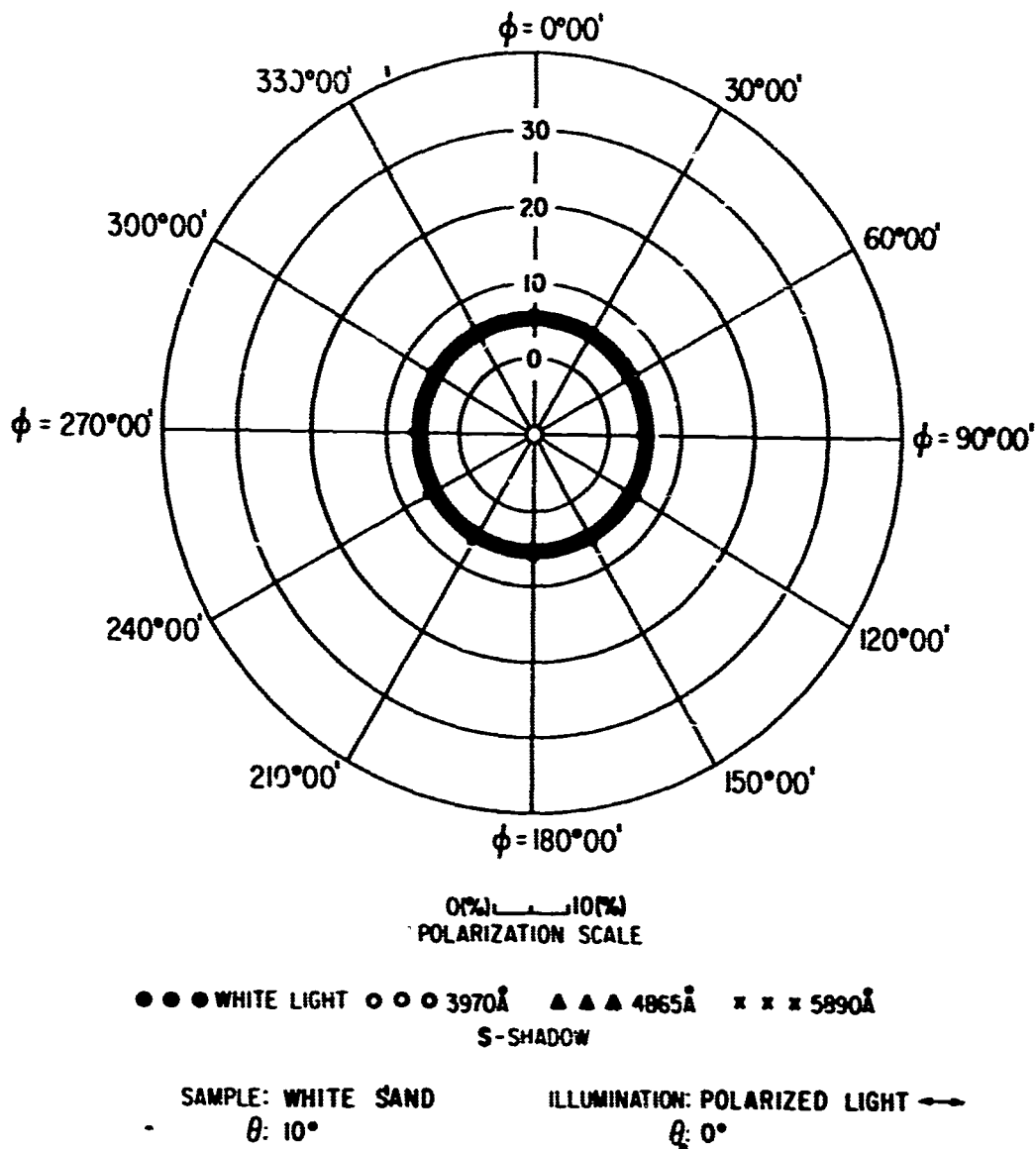
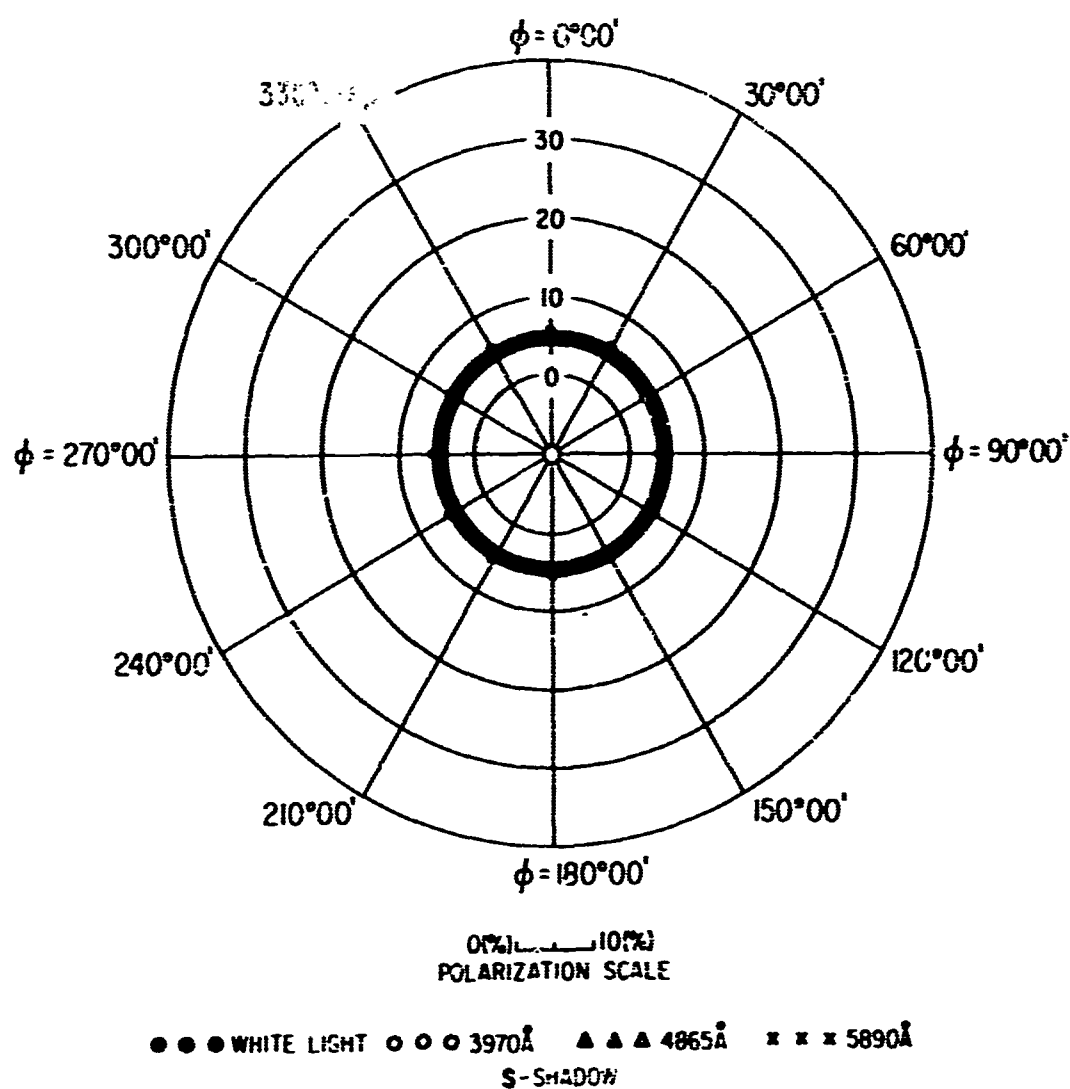


FIG 118. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.08 + 0.02 \cos \phi + 0.11 \cos 2\phi + 0.03 \cos 3\phi - 0.01 \cos 4\phi + 0.05 \cos 5\phi \\
 & + 0.03 \cos 6\phi - 0.10 \sin \phi - 0.16 \sin 2\phi - 0.03 \sin 3\phi + 0.02 \sin 4\phi + 0.02 \sin 5\phi
 \end{aligned}$$



SAMPLE: WHITE SAND
 $\theta: 20^\circ$

ILLUMINATION: POLARIZED LIGHT \longleftrightarrow
 $\theta_i: 0^\circ$

FIG 119. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 4.50 + 0.11 \cos \varphi + 0.19 \cos 2\varphi + 0.07 \cos 3\varphi + 0.08 \cos 4\varphi + 0.02 \cos 5\varphi \\
- 0.13 \cos 6\varphi - 0.04 \sin \varphi - 0.07 \sin 2\varphi - 0.03 \sin 3\varphi - 0.07 \sin 4\varphi - 0.04 \sin 5\varphi$$

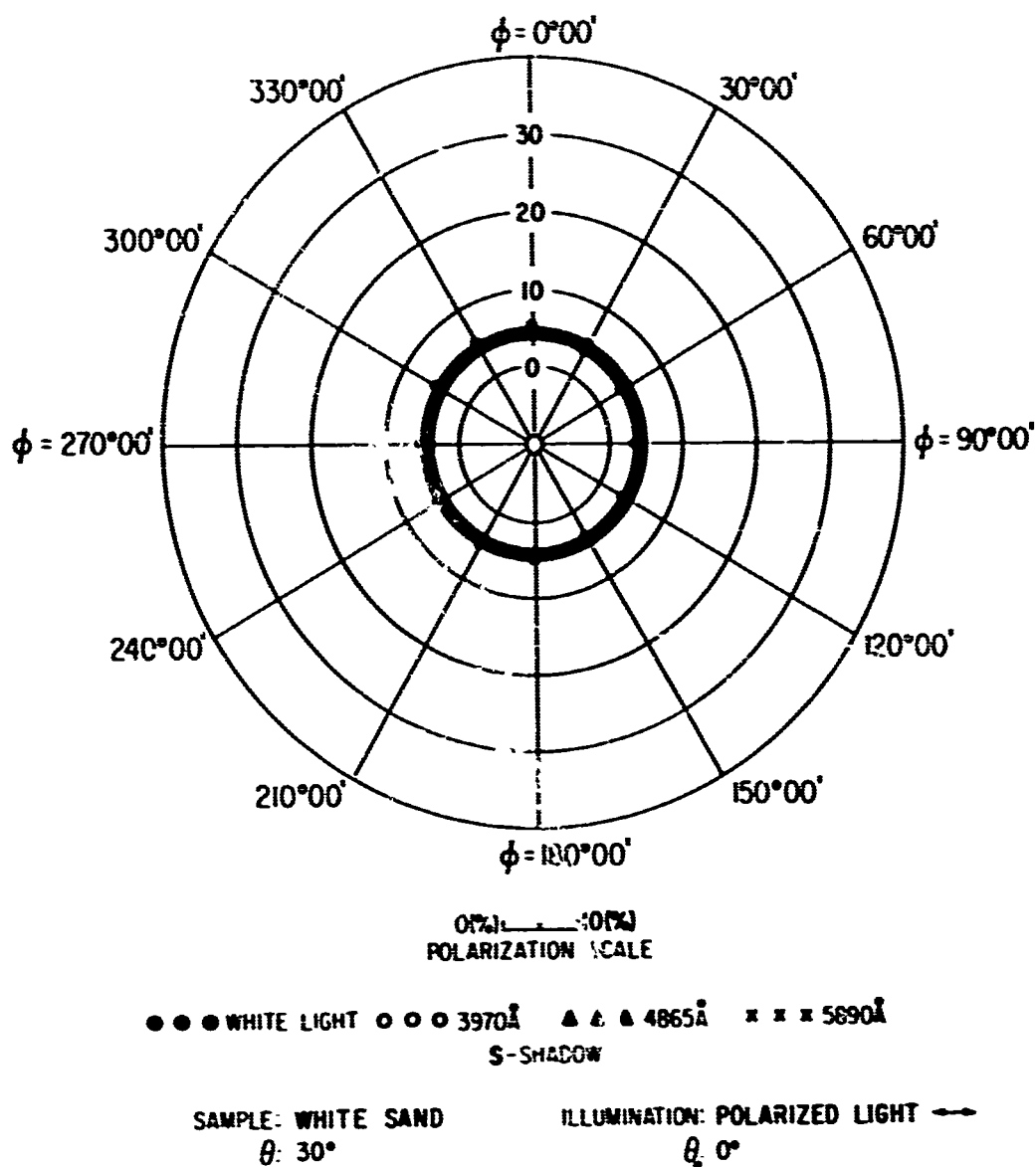


FIG 120. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 4.15 + 0.08 \cos \varphi + 0.34 \cos 2\varphi - 0.05 \cos 3\varphi + 0.08 \cos 4\varphi + 0.08 \cos 5\varphi \\ + 0.07 \cos 6\varphi - 0.20 \sin \varphi - 0.10 \sin 2\varphi - 0.08 \sin 3\varphi + 0.10 \sin 4\varphi + 0.06 \sin 5\varphi$$

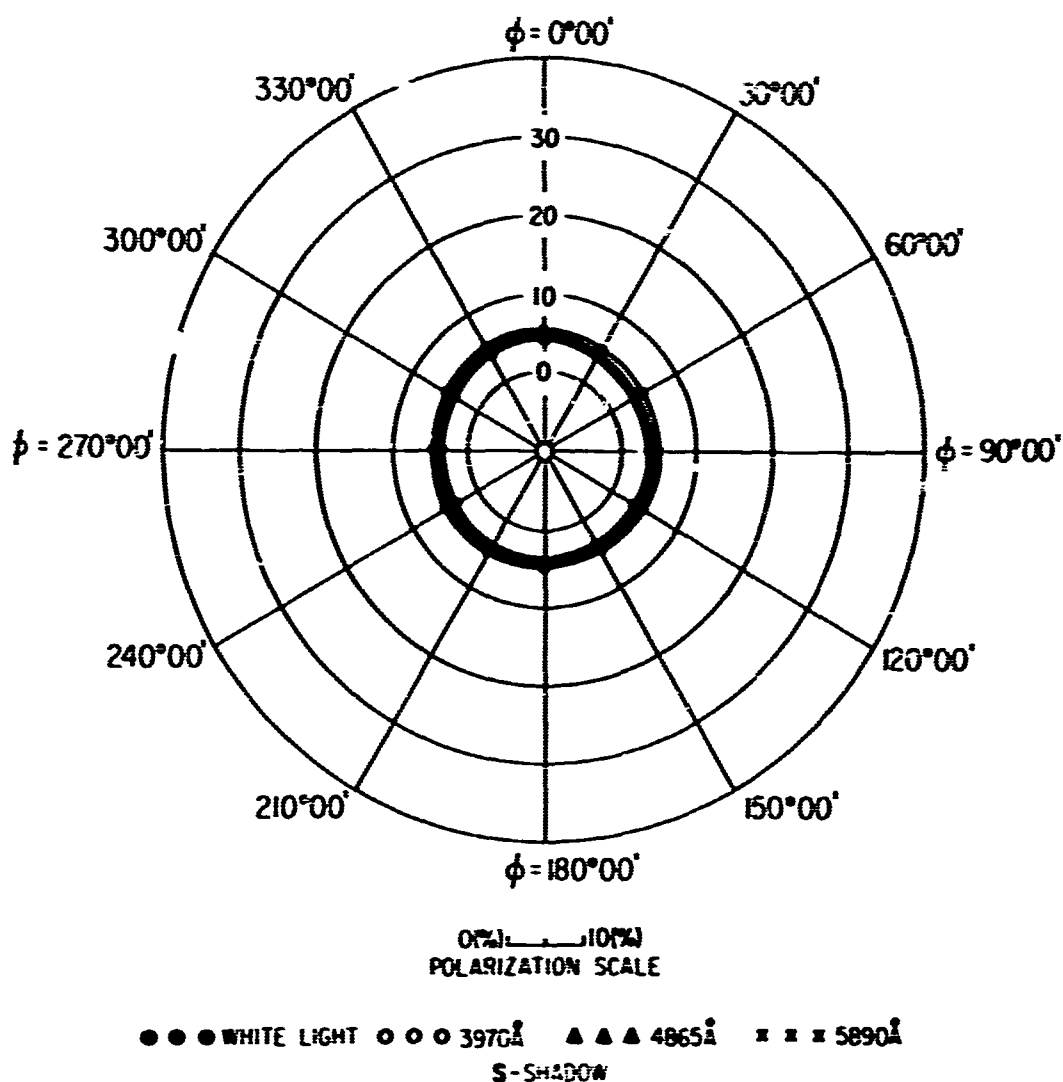


FIG 121. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 3.87 + 0.08 \cos \varphi + 0.52 \cos 2\varphi - 0.03 \cos 3\varphi + 0.26 \cos 4\varphi + 0.05 \cos 5\varphi \\ + 0.00 \cos 6\varphi - 0.06 \sin \varphi - 0.13 \sin 2\varphi + 0.03 \sin 3\varphi - 0.13 \sin 4\varphi - 0.06 \sin 5\varphi$$

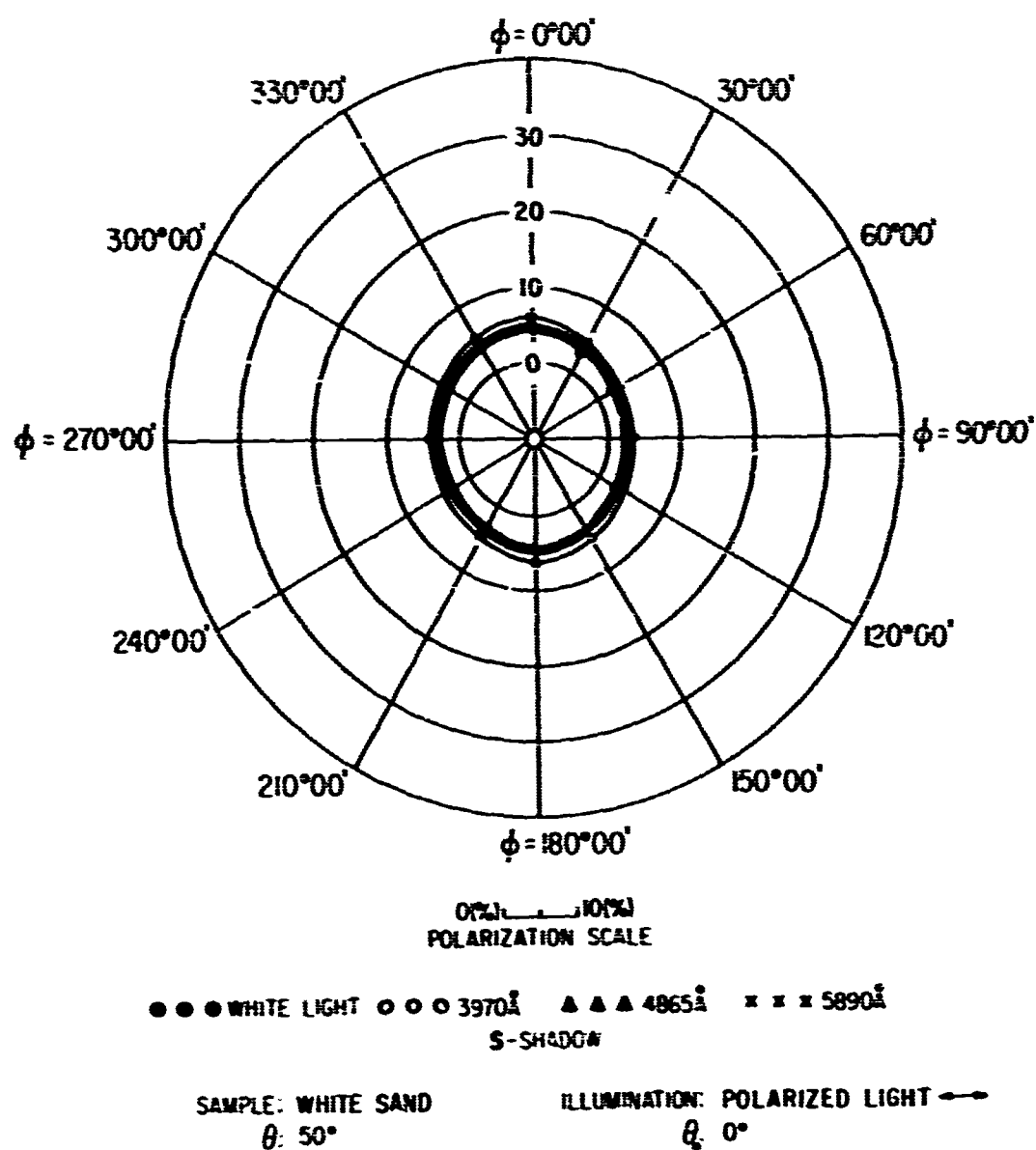


FIG 122. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 3.72 - 0.03 \cos \varphi + 0.78 \cos 2\varphi + 0.07 \cos 3\varphi + 0.18 \cos 4\varphi - 0.09 \cos 5\varphi \\
 & - 0.05 \cos 6\varphi - 0.06 \sin \varphi - 0.10 \sin 2\varphi - 0.02 \sin 3\varphi - 0.13 \sin 4\varphi - 0.01 \sin 5\varphi
 \end{aligned}$$

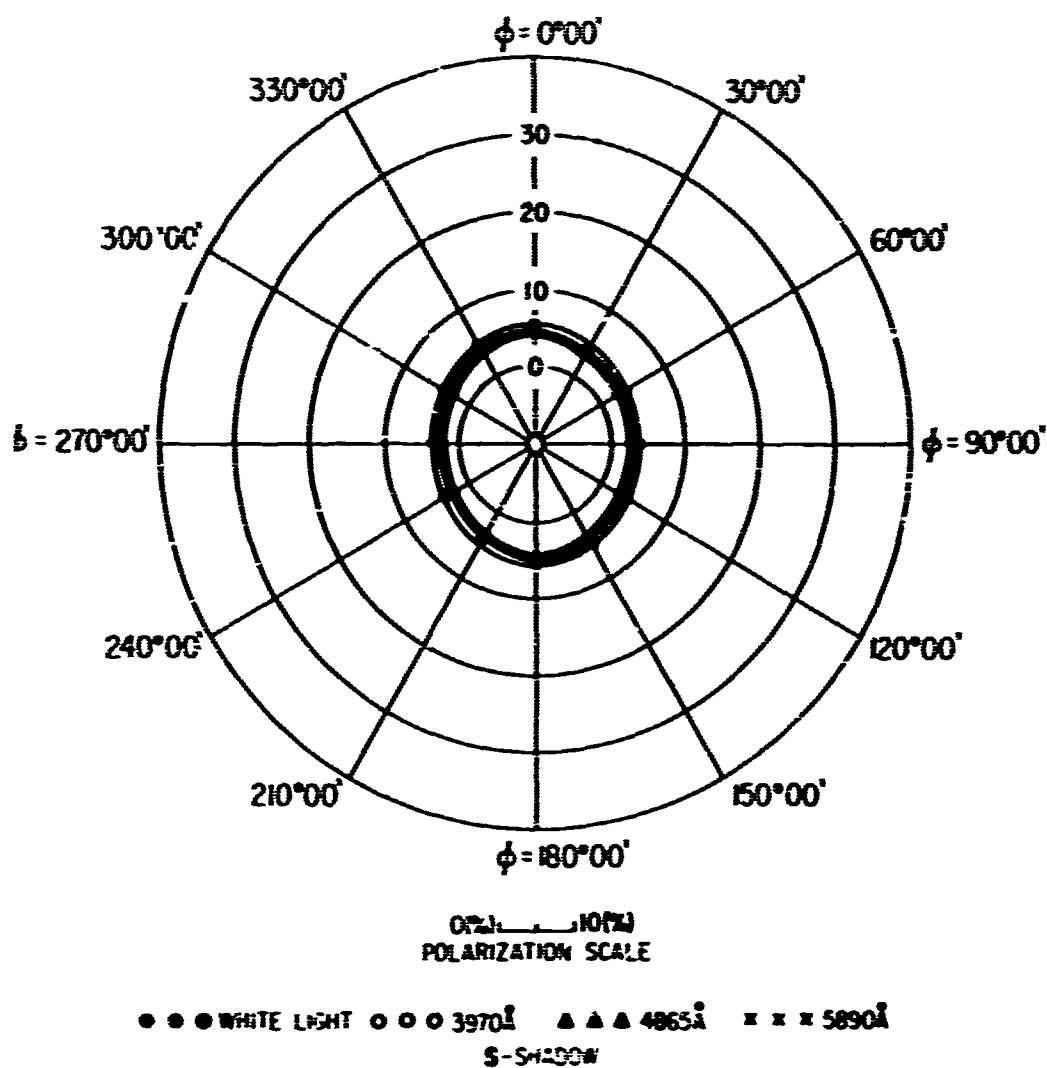


FIG 123. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 3.65 - 0.07 \cos \phi + 0.92 \cos 2\phi - 0.05 \cos 3\phi + 0.58 \cos 4\phi + 0.07 \cos 5\phi \\
 & - 0.00 \cos 6\phi - 0.02 \sin \phi - 0.30 \sin 2\phi - 0.08 \sin 3\phi - 0.19 \sin 4\phi + 0.04 \sin 5\phi
 \end{aligned}$$

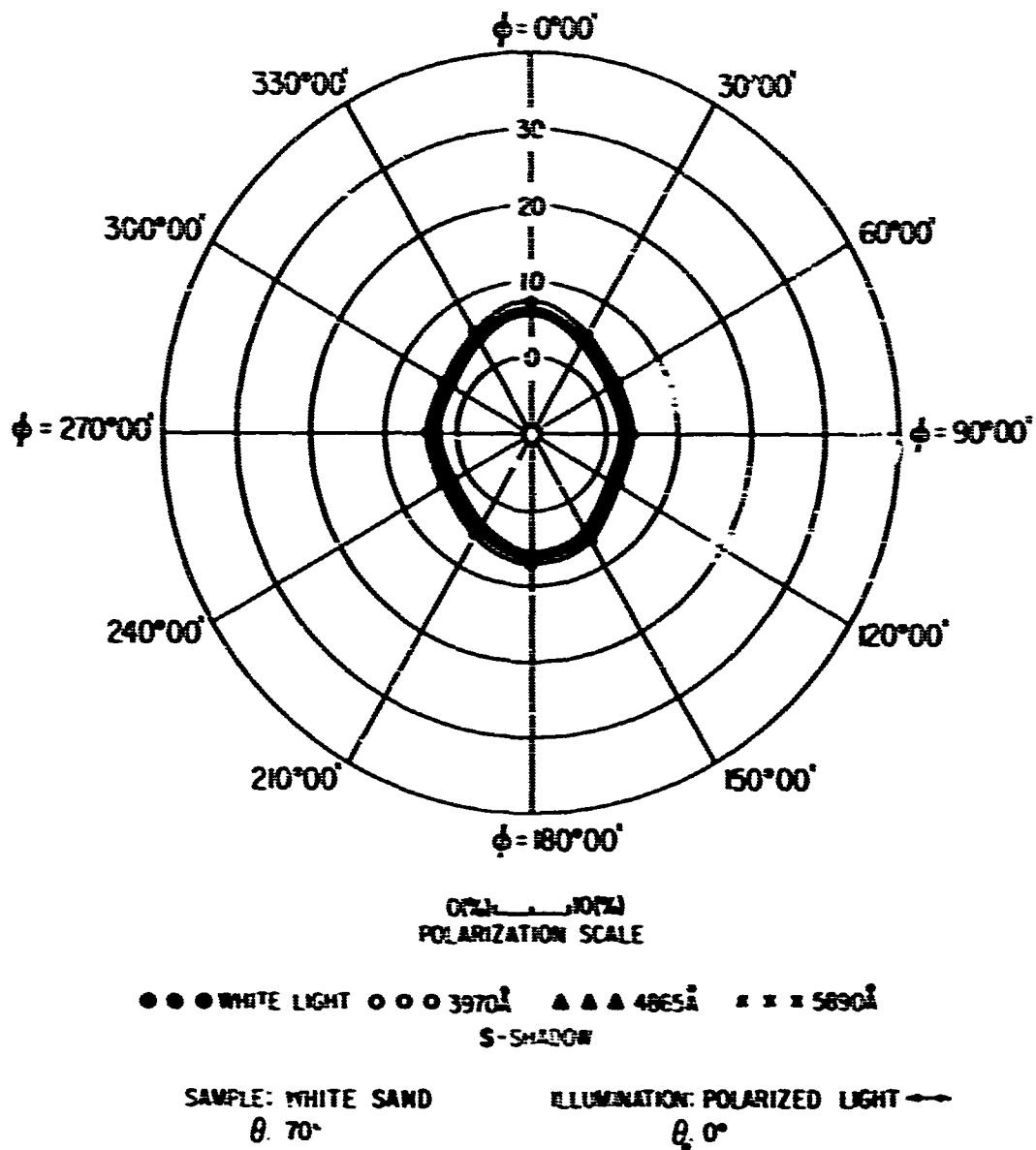


FIG 124. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 3.97 - 0.01 \cos \phi + 1.16 \cos 2\phi + 0.13 \cos 3\phi + 0.81 \cos 4\phi + 0.08 \cos 5\phi \\ - 0.13 \cos 6\phi + 0.25 \sin \phi - 0.33 \sin 2\phi - 0.17 \sin 3\phi - 0.27 \sin 4\phi + 0.14 \sin 5\phi$$

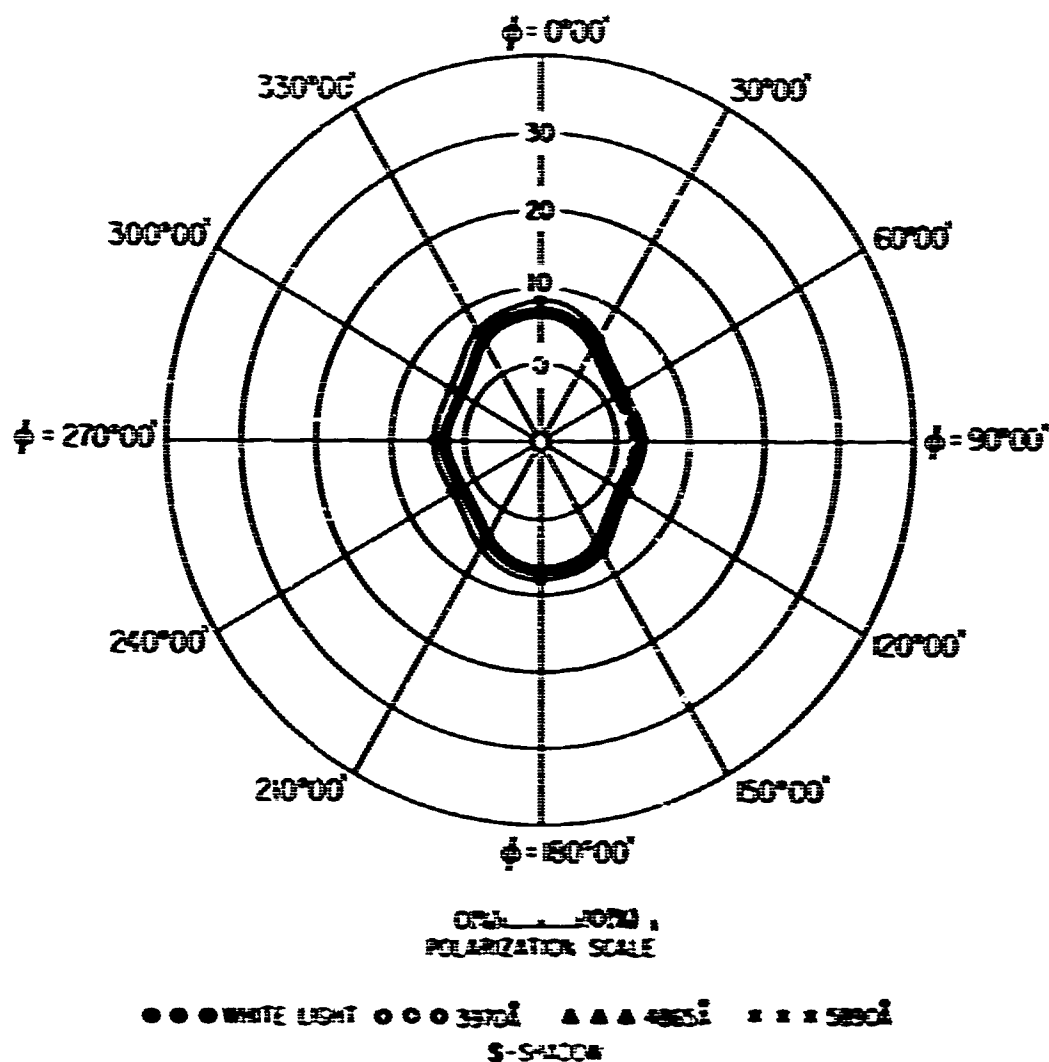


FIG 125. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 4.22 \pm 0.00 \cos \phi + 1.52 \cos 2\phi - 0.15 \cos 3\phi + 0.95 \cos 4\phi + 0.00 \cos 5\phi \\
 & - 0.46 \cos 6\phi + 0.14 \sin \phi - 0.37 \sin 2\phi - 0.10 \sin 3\phi - 0.32 \sin 4\phi - 0.04 \sin 5\phi
 \end{aligned}$$

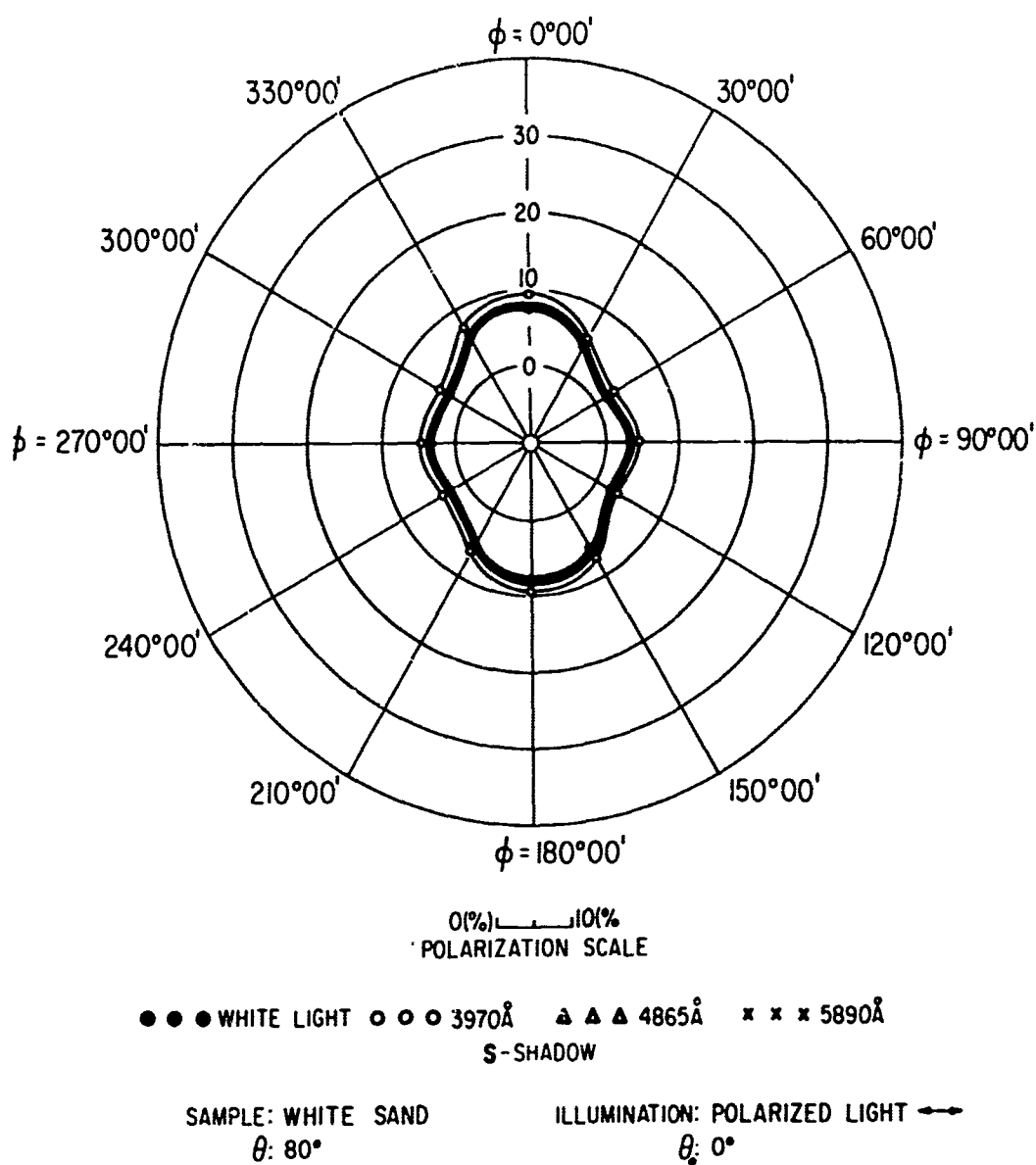


FIG 126. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 4.78 - 0.05 \cos \phi + 1.69 \cos 2\phi - 0.13 \cos 3\phi + 1.02 \cos 4\phi - 0.15 \cos 5\phi \\
 & - 0.28 \cos 6\phi + 0.22 \sin \phi - 0.36 \sin 2\phi - 0.22 \sin 3\phi - 0.51 \sin 4\phi + 0.02 \sin 5\phi
 \end{aligned}$$

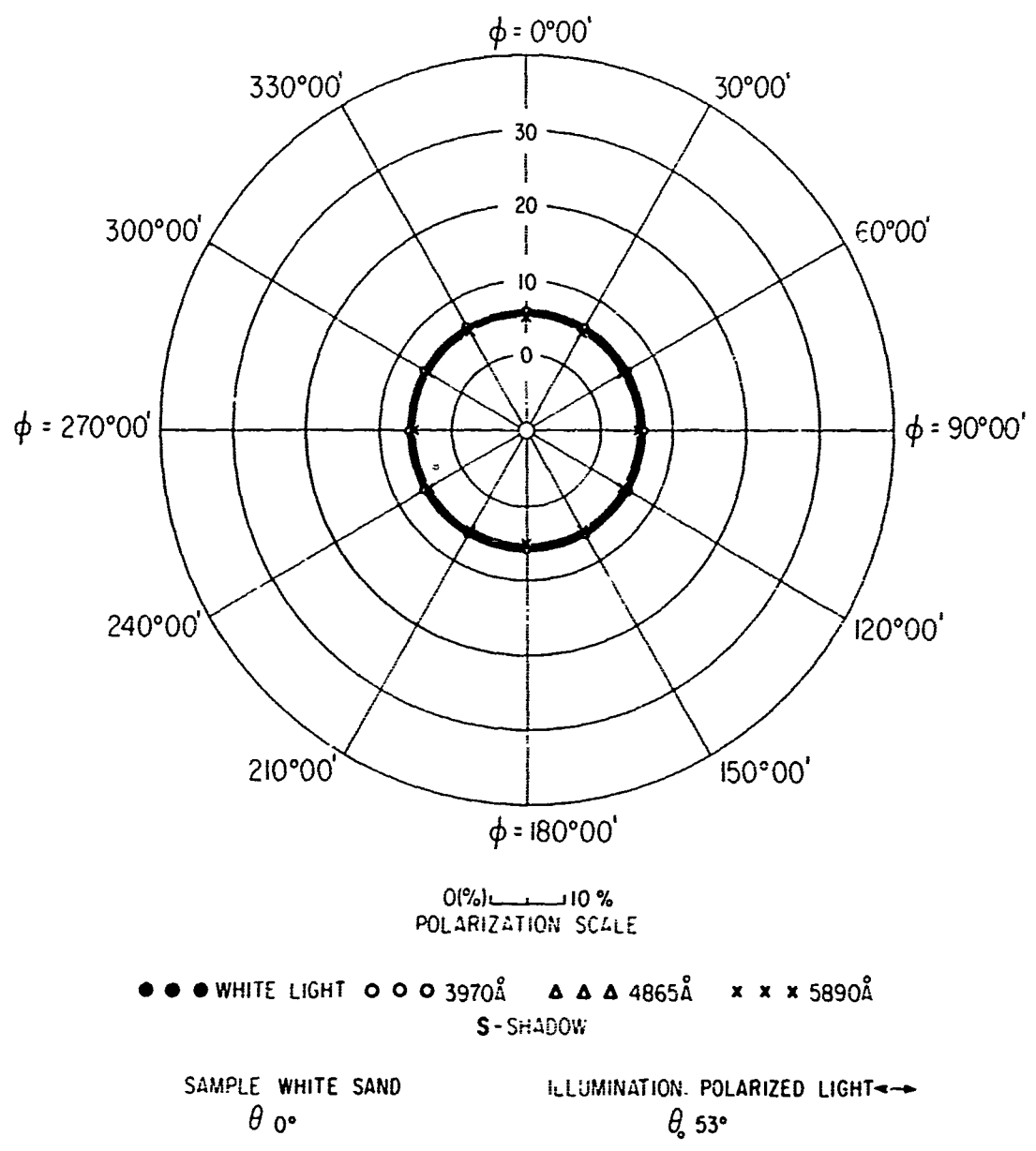


FIG 127 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

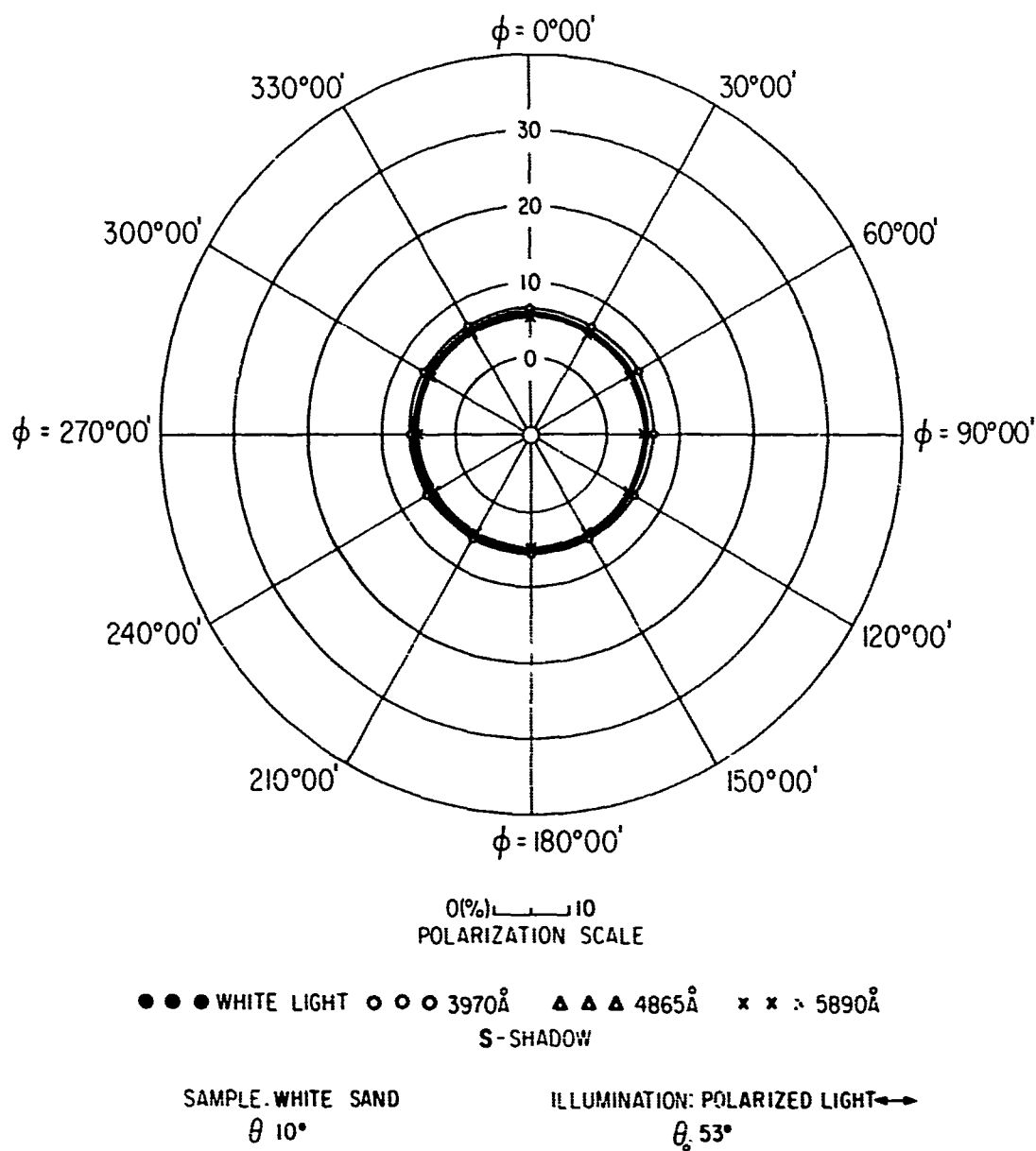
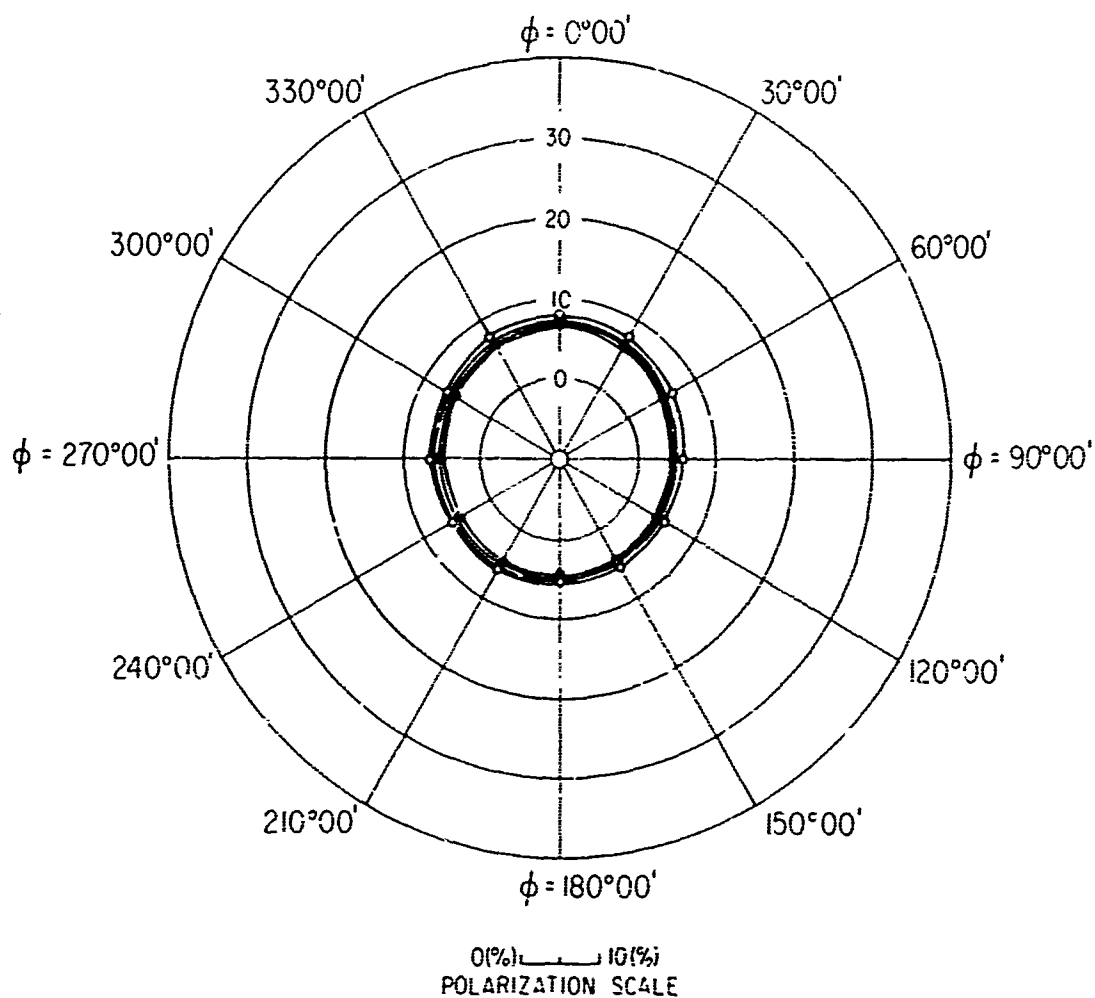


FIG 128 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 5.62 - 0.12 \cos \varphi + 0.25 \cos 2\varphi - 0.05 \cos 3\varphi + 0.05 \cos 4\varphi + 0.03 \cos 5\varphi \\ + 0.05 \cos 6\varphi + 0.01 \sin \varphi + 0.09 \sin 2\varphi - 0.03 \sin 3\varphi - 0.03 \sin 4\varphi - 0.04 \sin 5\varphi$$



● ● ● WHITE LIGHT ○ ○ ○ 3970 Å △ △ △ 4865 Å × × × 5890 Å
 S-SHADOW

SAMPLE WHITE SAND
 $\theta = 20^\circ$

ILLUMINATION POLARIZED LIGHT \longleftrightarrow
 $\theta_i = 53^\circ$

FIG 129 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 5.51 + 1.08 \cos \varphi + 0.70 \cos 2\varphi + 0.02 \cos 3\varphi + 0.02 \cos 4\varphi + 0.01 \cos 5\varphi \\
 & - 0.05 \cos 6\varphi - 0.08 \sin \varphi - 0.03 \sin 2\varphi + 0.03 \sin 3\varphi - 0.12 \sin 4\varphi + 0.06 \sin 5\varphi
 \end{aligned}$$

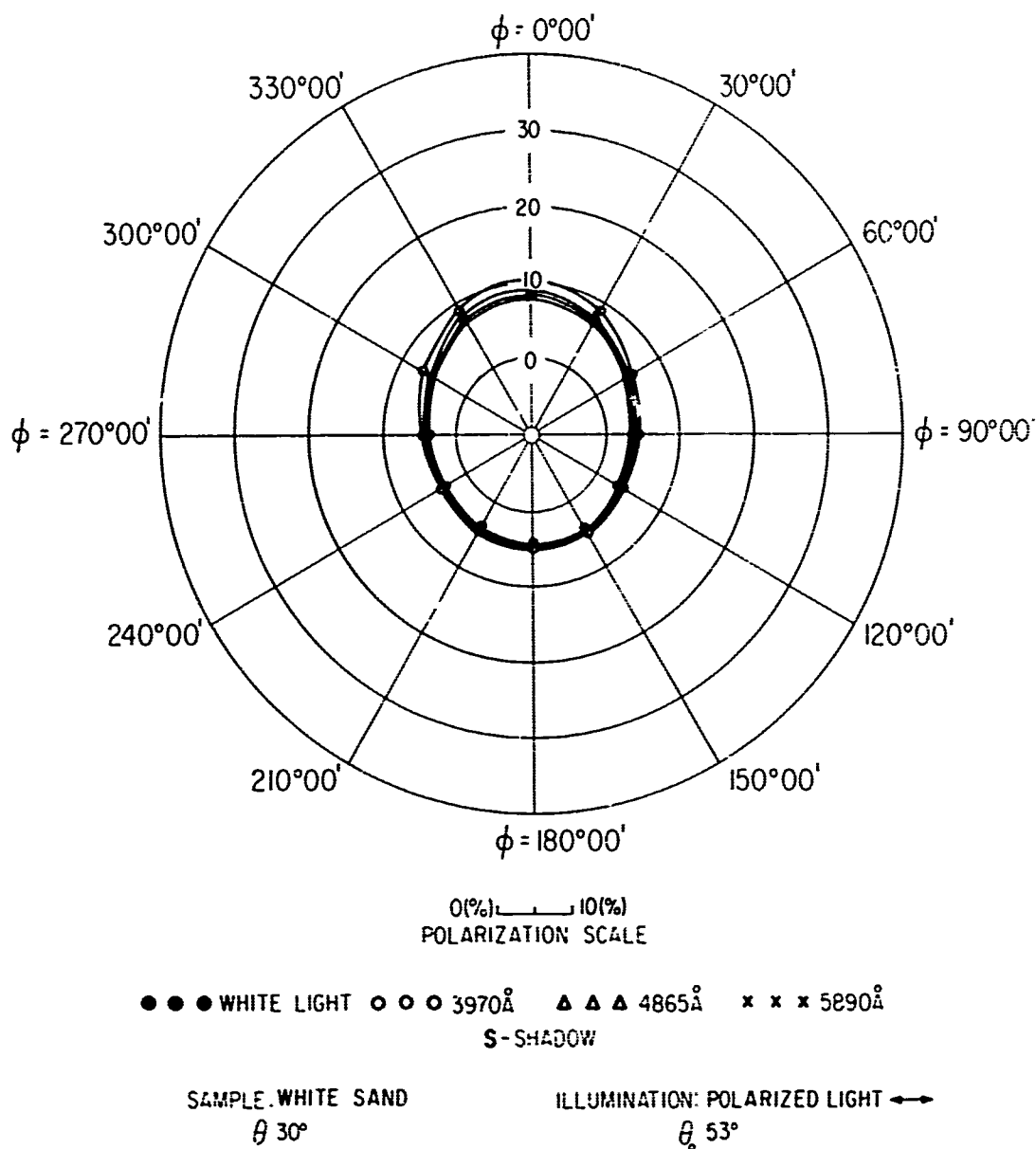


FIG 130 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 5.50 + 1.57 \cos \varphi + 1.36 \cos 2\varphi + 0.08 \cos 3\varphi - 0.03 \cos 4\varphi + 0.10 \cos 5\varphi \\ + 0.03 \cos 6\varphi - 0.14 \sin \varphi - 0.04 \sin 2\varphi + 0.08 \sin 3\varphi + 0.01 \sin 4\varphi - 0.08 \sin 5\varphi$$

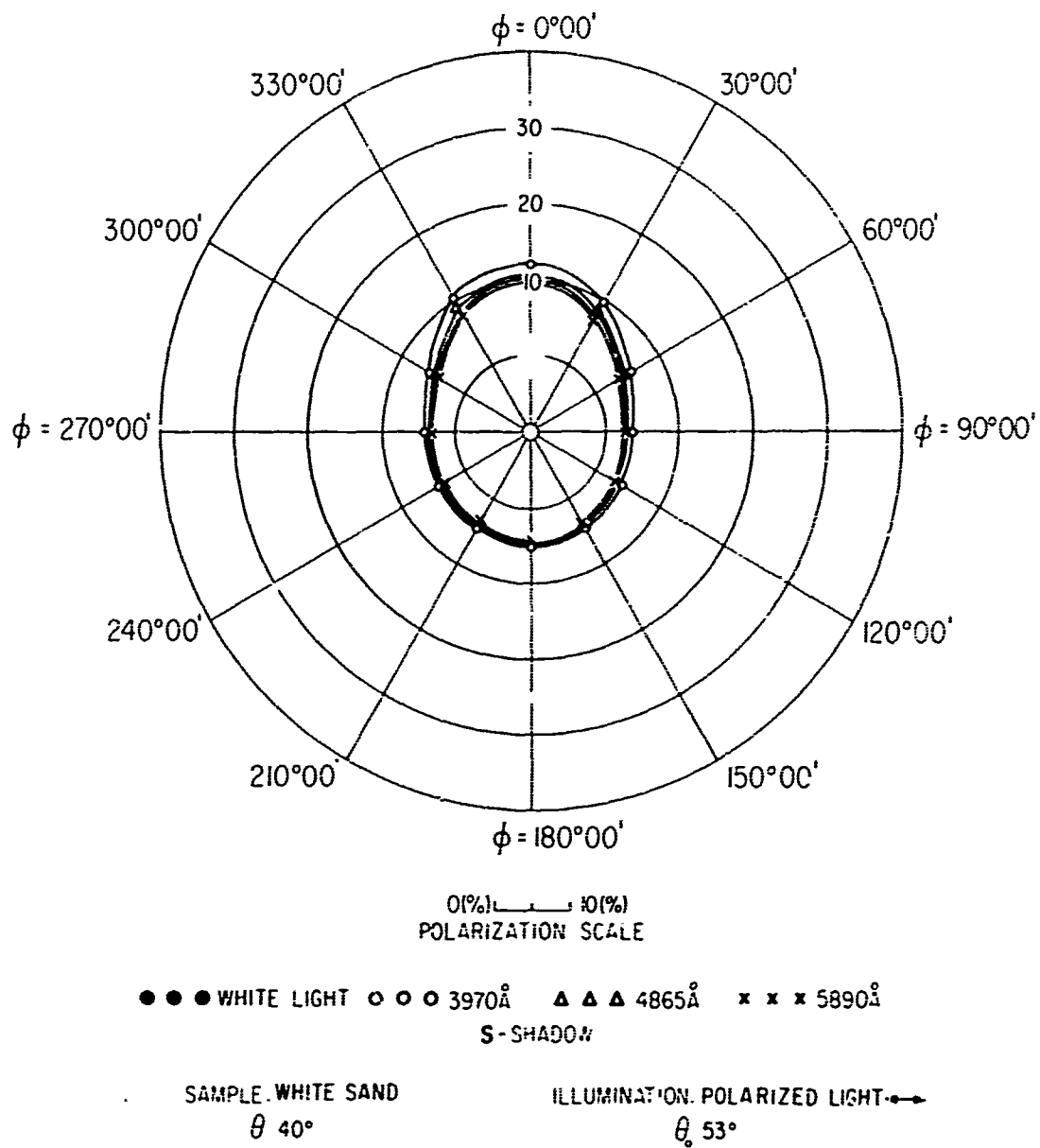


FIG 131 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 5.52 + 2.06 \cos \varphi + 2.23 \cos 2\varphi + 0.43 \cos 3\varphi + 0.05 \cos 4\varphi - 0.04 \cos 5\varphi \\
 & + 0.08 \cos 6\varphi - 0.22 \sin \varphi + 0.06 \sin 2\varphi - 0.08 \sin 3\varphi + 0.03 \sin 4\varphi + 0.04 \sin 5\varphi
 \end{aligned}$$

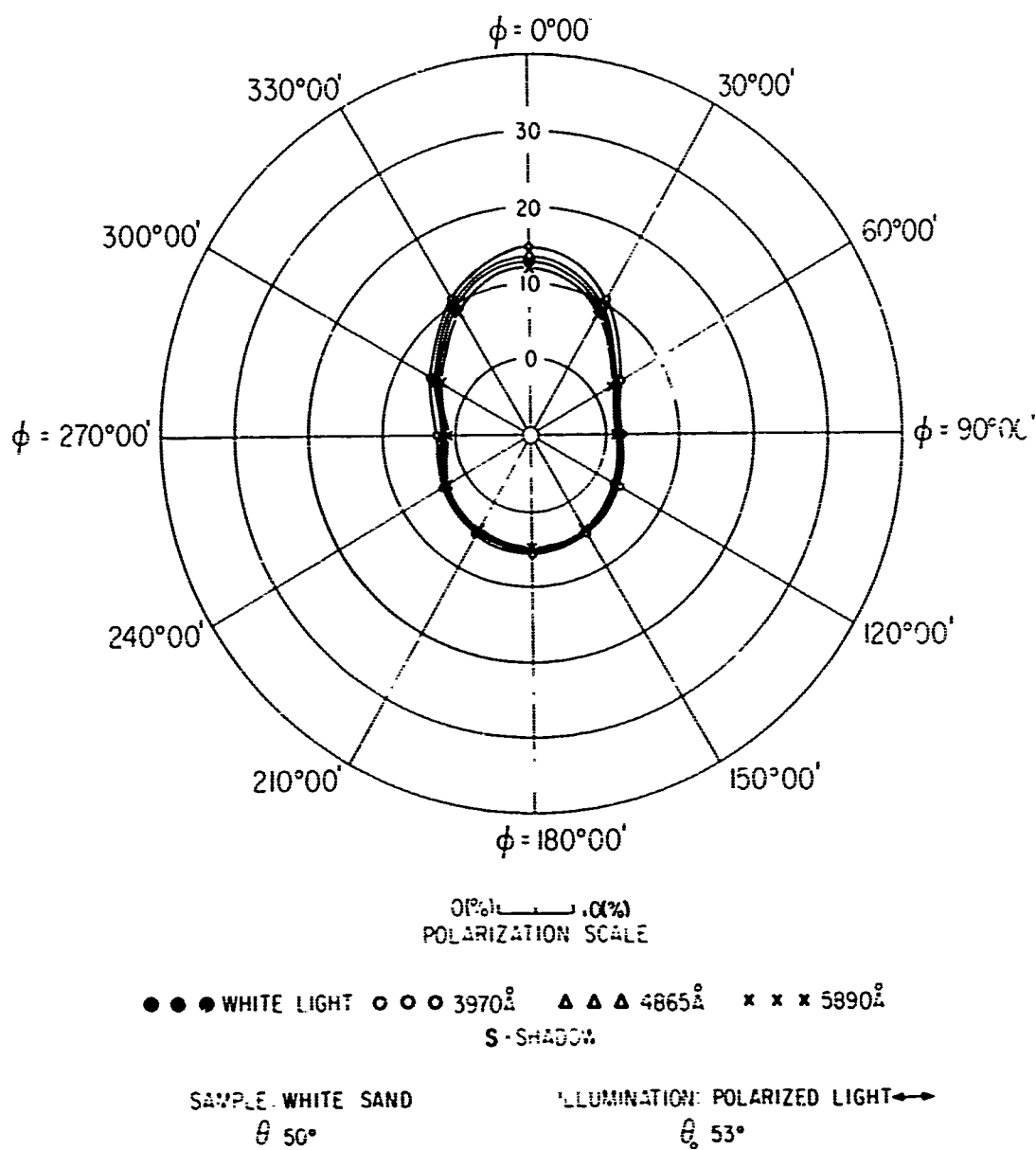
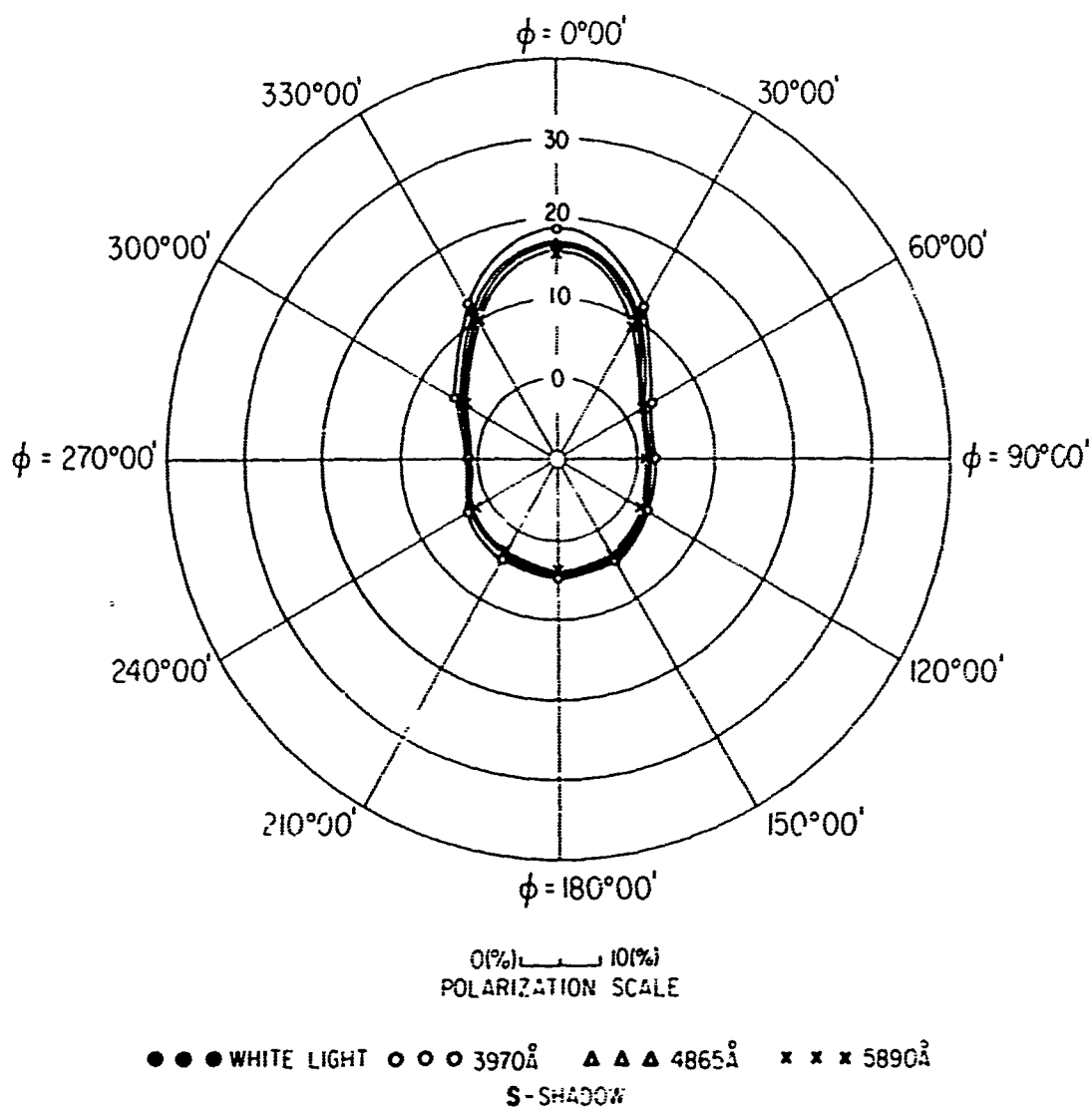


FIG 132 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 5.5\delta + 2.71 \cos \varphi + 3.19 \cos 2\varphi + 1.00 \cos 3\varphi + 0.09 \cos 4\varphi - 0.04 \cos 5\varphi \\
 & + 0.01 \cos 6\varphi - 0.27 \sin \varphi - 0.07 \sin 2\varphi + 0.08 \sin 3\varphi + 0.07 \sin 4\varphi + 0.10 \sin 5\varphi
 \end{aligned}$$



SAMPLE WHITE SAND
 $\theta 60^{\circ}$

ILLUMINATION POLARIZED LIGHT →
 $\theta_i 53^{\circ}$

FIG 133 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 5.70 + 3.66 \cos \varphi + 4.42 \cos 2\varphi + 1.82 \cos 3\varphi + 0.48 \cos 4\varphi + 0.17 \cos 5\varphi \\
 & + 0.10 \cos 6\varphi - 0.29 \sin \varphi - 0.19 \sin 2\varphi - 0.08 \sin 3\varphi - 0.10 \sin 4\varphi + 0.11 \sin 5\varphi
 \end{aligned}$$

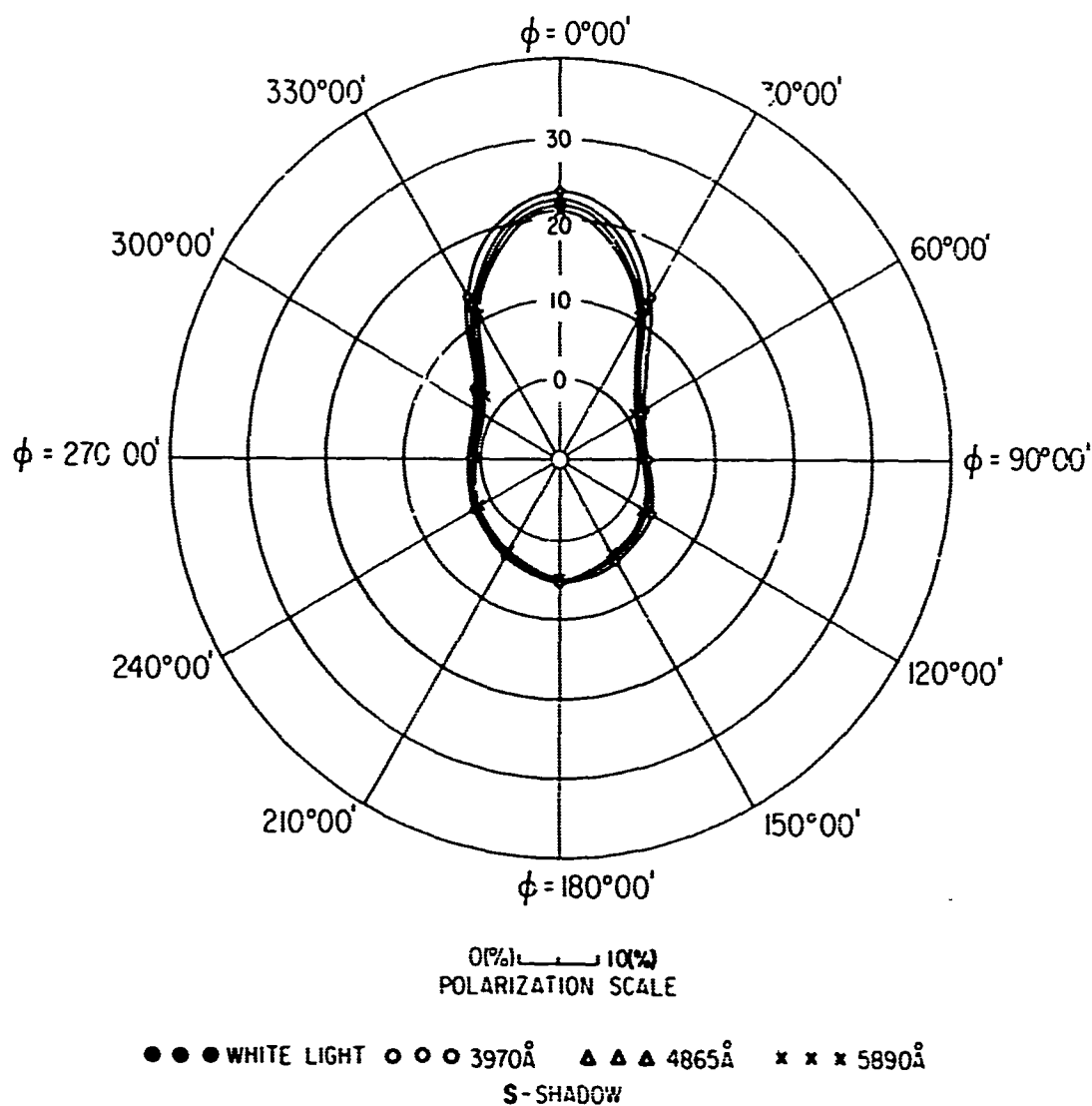
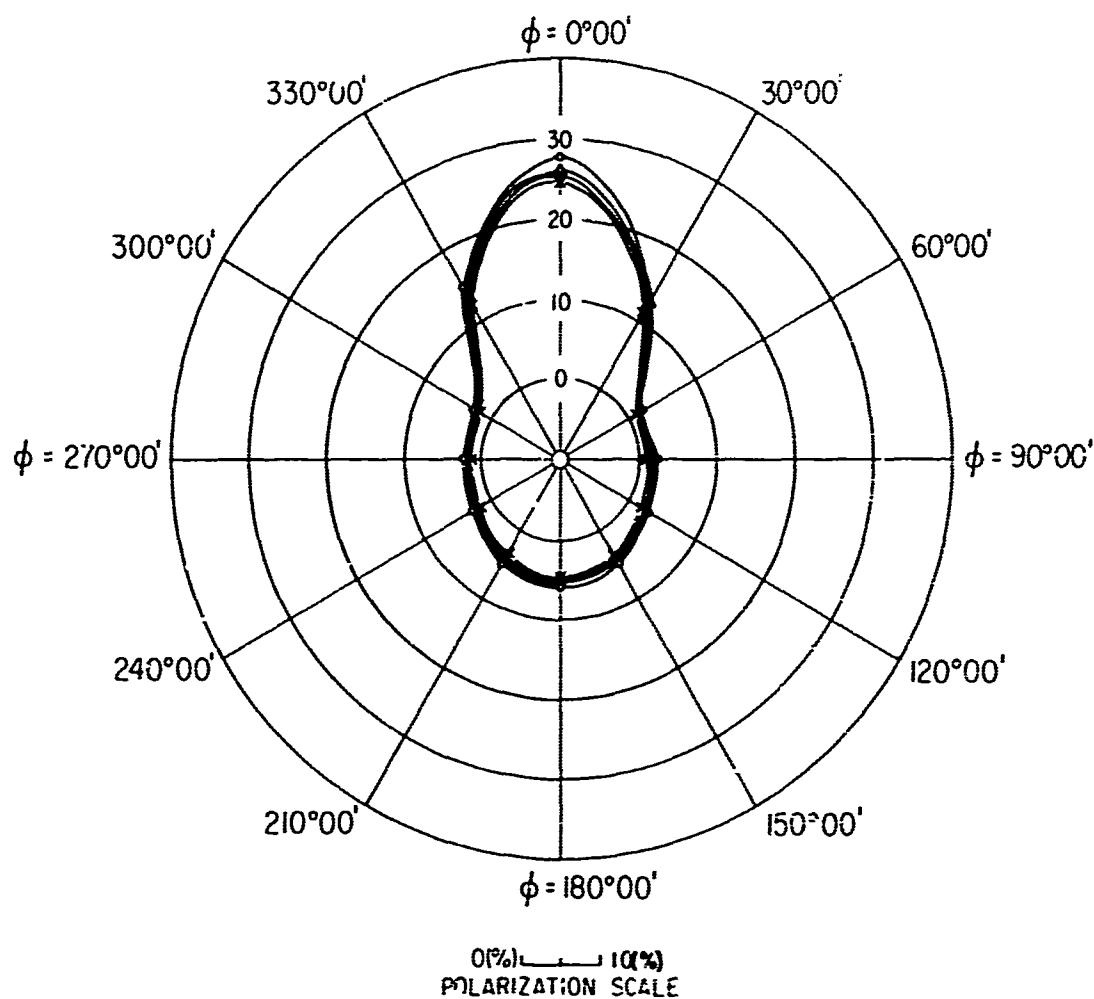


FIG 134 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.19 + 5.02 \cos \varphi + 5.74 \cos 2\varphi + 2.85 \cos 3\varphi + 1.66 \cos 4\varphi + 0.38 \cos 5\varphi \\
 & + 0.32 \cos 6\varphi - 0.31 \sin \varphi - 0.10 \sin 2\varphi - 0.07 \sin 3\varphi + 0.07 \sin 4\varphi + 0.10 \sin 5\varphi
 \end{aligned}$$



● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
S-SHADOW

SAMPLE. WHITE SAND
 $\theta = 75^\circ$

ILLUMINATION: POLARIZED LIGHT \longleftrightarrow
 $\theta_i = 53^\circ$

FIG. 135 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 6.48 + 5.50 \cos \varphi + 5.90 \cos 2\varphi + 2.88 \cos 3\varphi + 1.57 \cos 4\varphi + 0.17 \cos 5\varphi \\ + 0.00 \cos 6\varphi - 0.21 \sin \varphi - 0.18 \sin 2\varphi + 0.08 \sin 3\varphi + 0.07 \sin 4\varphi + 0.14 \sin 5\varphi$$

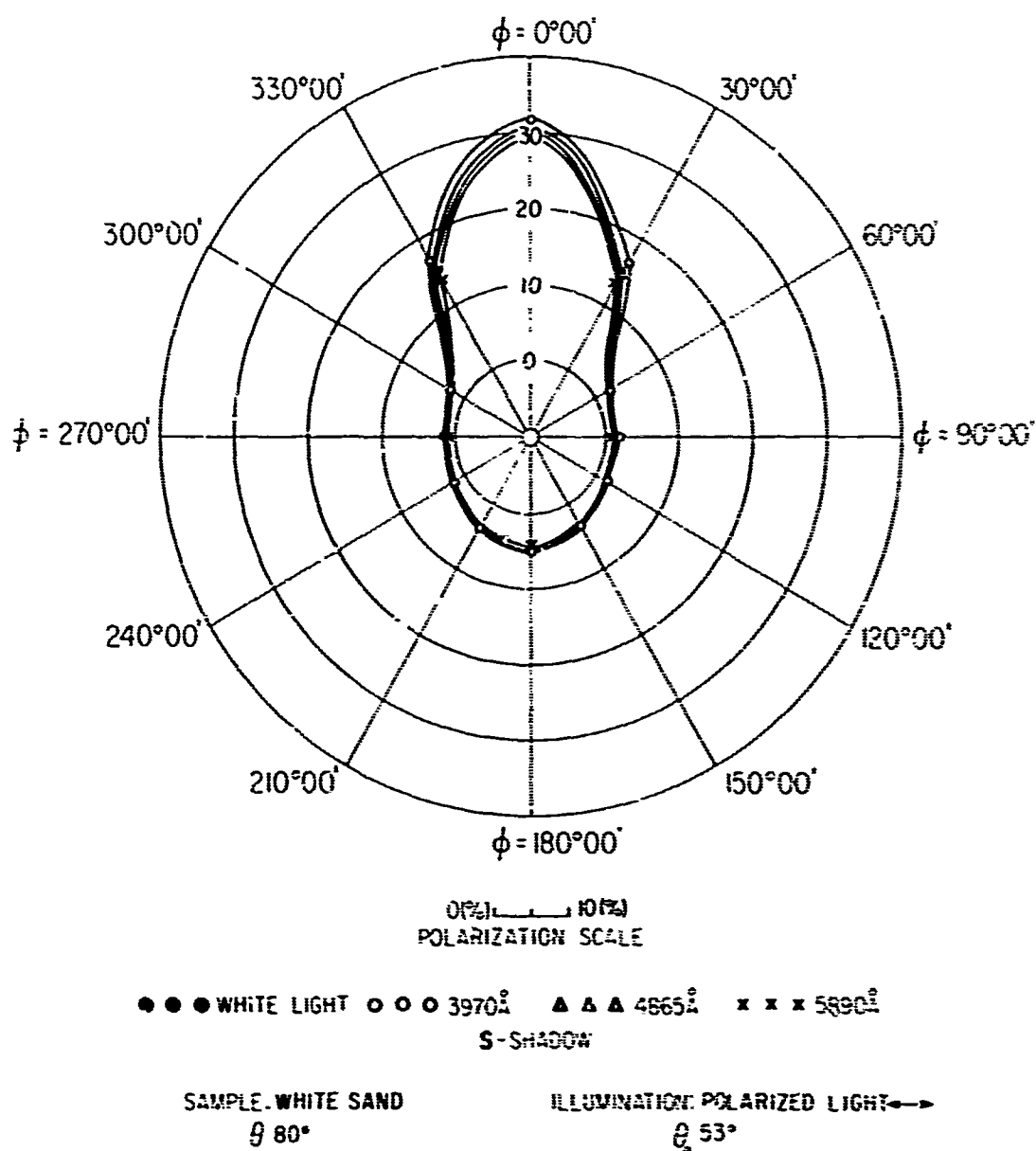


FIG 136 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 7.74 + 7.60 \cos \phi + 7.28 \cos 2\phi + 4.47 \cos 3\phi + 3.11 \cos 4\phi + 1.49 \cos 5\phi \\
 & + 1.45 \cos 6\phi - 0.30 \sin \phi + 0.18 \sin 2\phi - 0.32 \sin 3\phi - 0.60 \sin 4\phi - 0.16 \sin 5\phi
 \end{aligned}$$

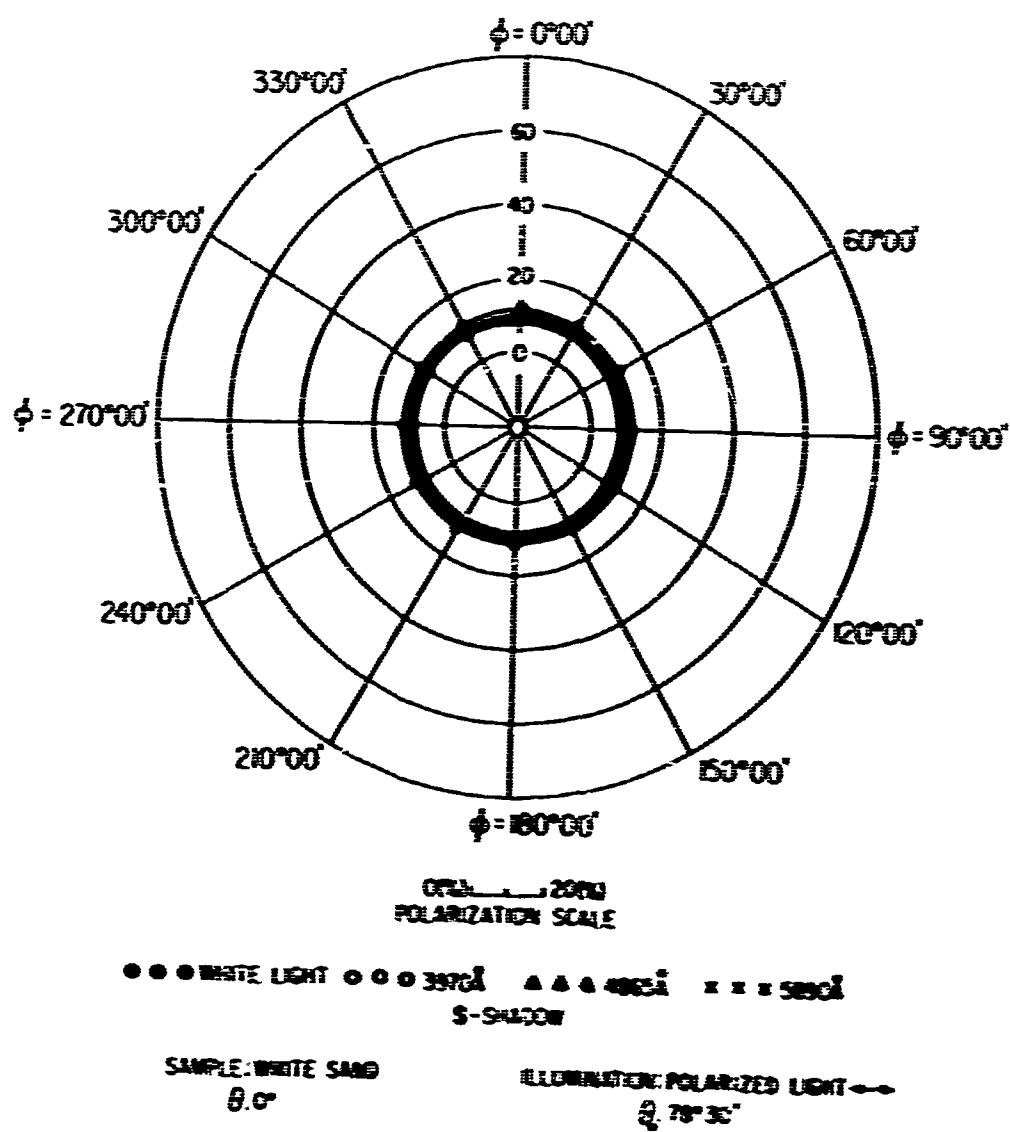


FIG. 137 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

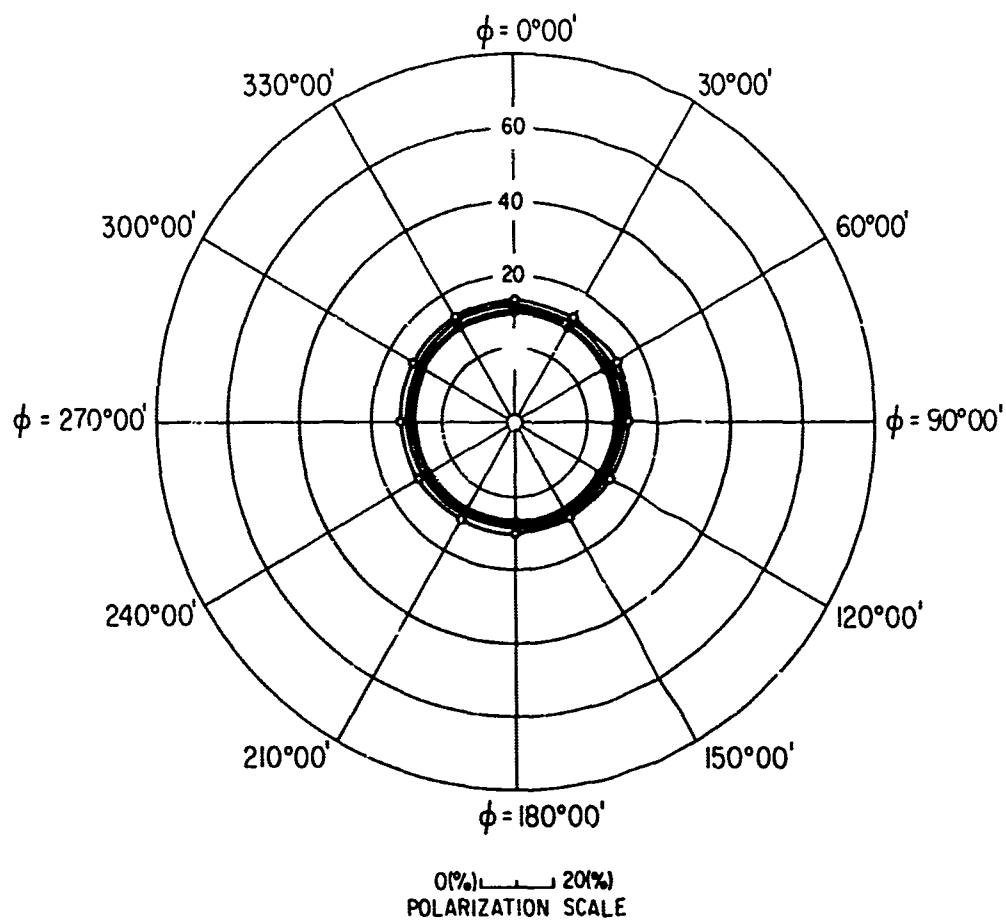


FIG.138 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 8.68 + 1.50 \cos \varphi + 0.27 \cos 2\varphi - 0.22 \cos 3\varphi - 0.05 \cos 4\varphi - 0.08 \cos 5\varphi \\
 & - 0.02 \cos 6\varphi - 0.38 \sin \varphi - 0.20 \sin 2\varphi - 0.03 \sin 3\varphi + 0.00 \sin 4\varphi + 0.00 \sin 5\varphi
 \end{aligned}$$

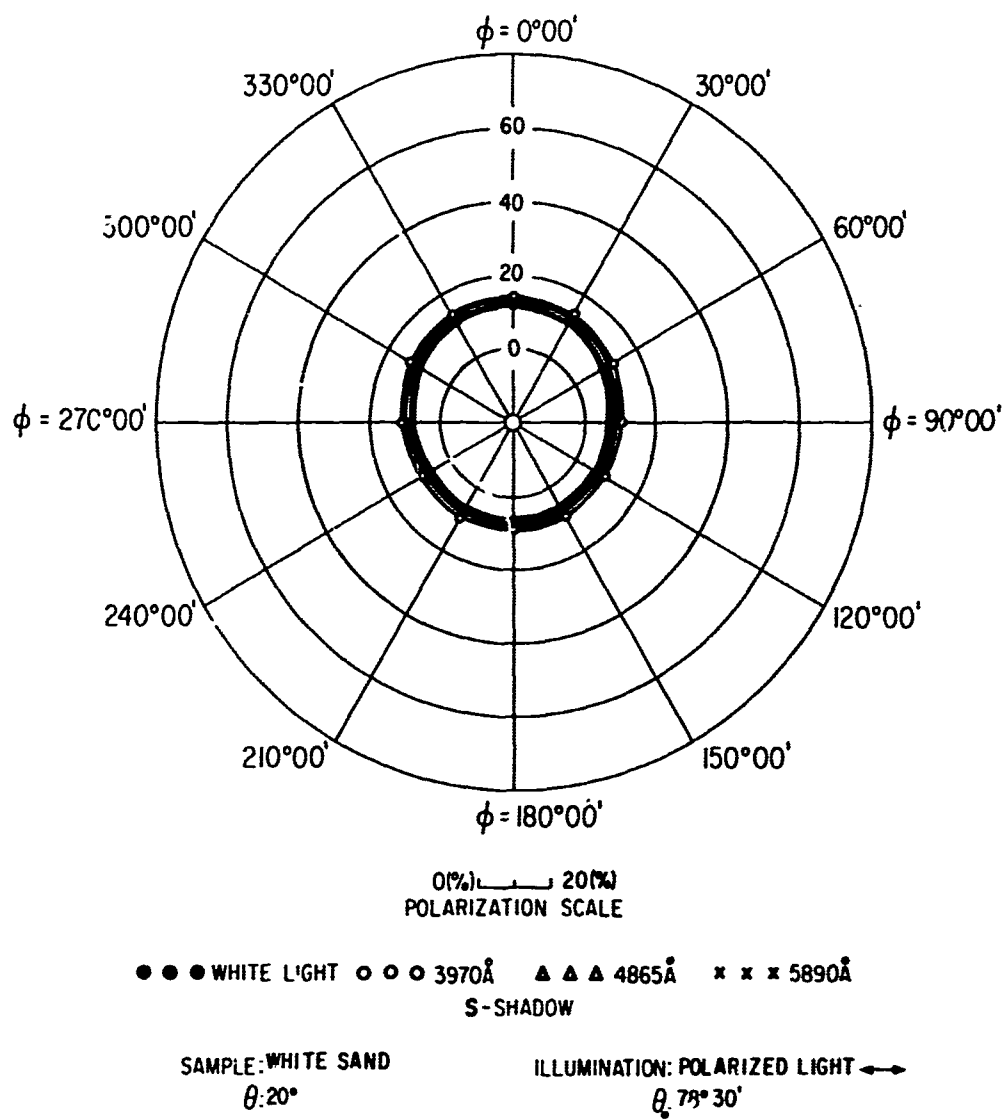


FIG 139 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 8.60 + 3.04 \cos \phi + 1.01 \cos 2\phi - 0.27 \cos 3\phi - 0.02 \cos 4\phi - 0.02 \cos 5\phi \\
 & - 0.27 \cos 6\phi - 0.47 \sin \phi - 0.39 \sin 2\phi - 0.07 \sin 3\phi + 0.10 \sin 4\phi - 0.10 \sin 5\phi
 \end{aligned}$$

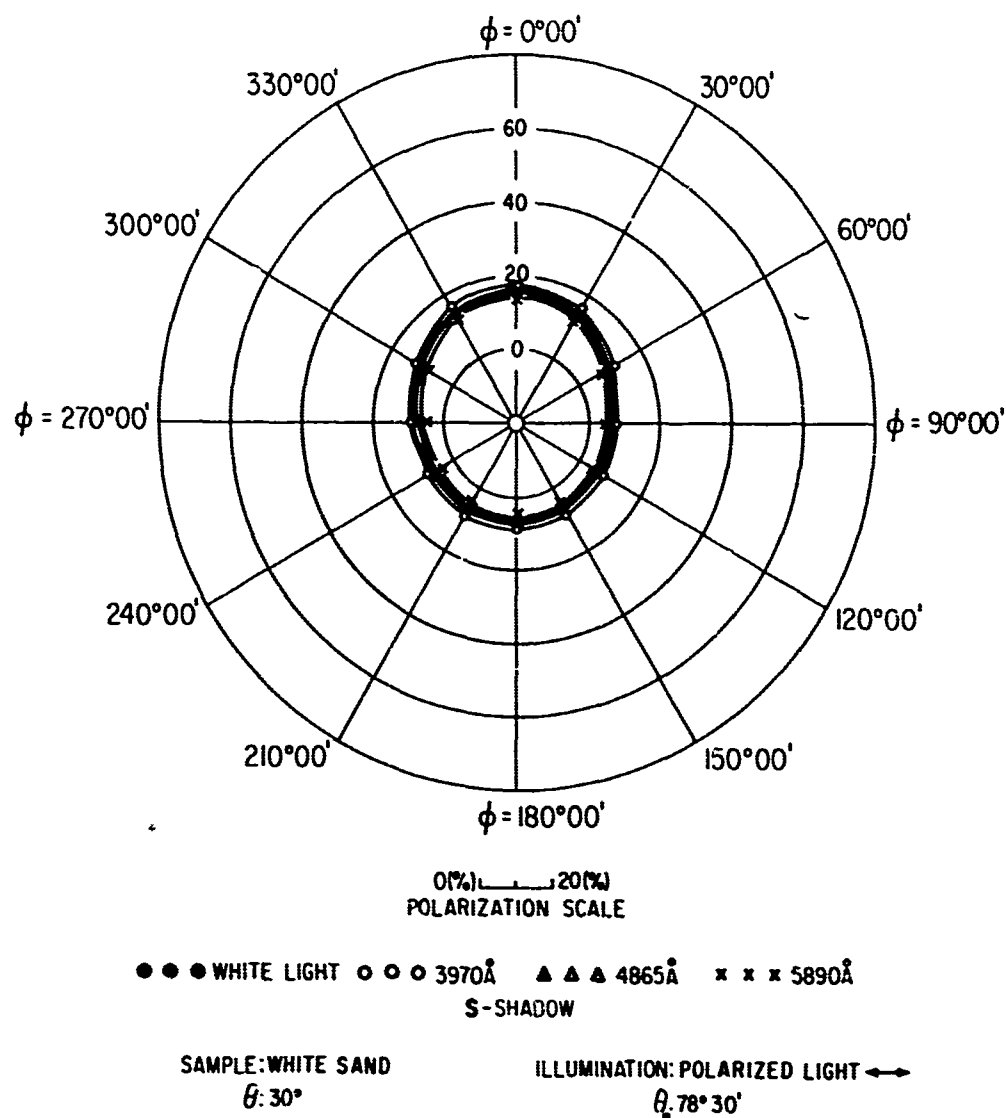


FIG. 140 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 8.64 + 4.40 \cos \varphi + 2.16 \cos 2\varphi + 0.40 \cos 3\varphi - 0.12 \cos 4\varphi - 0.16 \cos 5\varphi \\
 & + 0.18 \cos 6\varphi - 1.02 \sin \varphi - 0.22 \sin 2\varphi - 0.12 \sin 3\varphi - 0.18 \sin 4\varphi + 0.05 \sin 5\varphi
 \end{aligned}$$

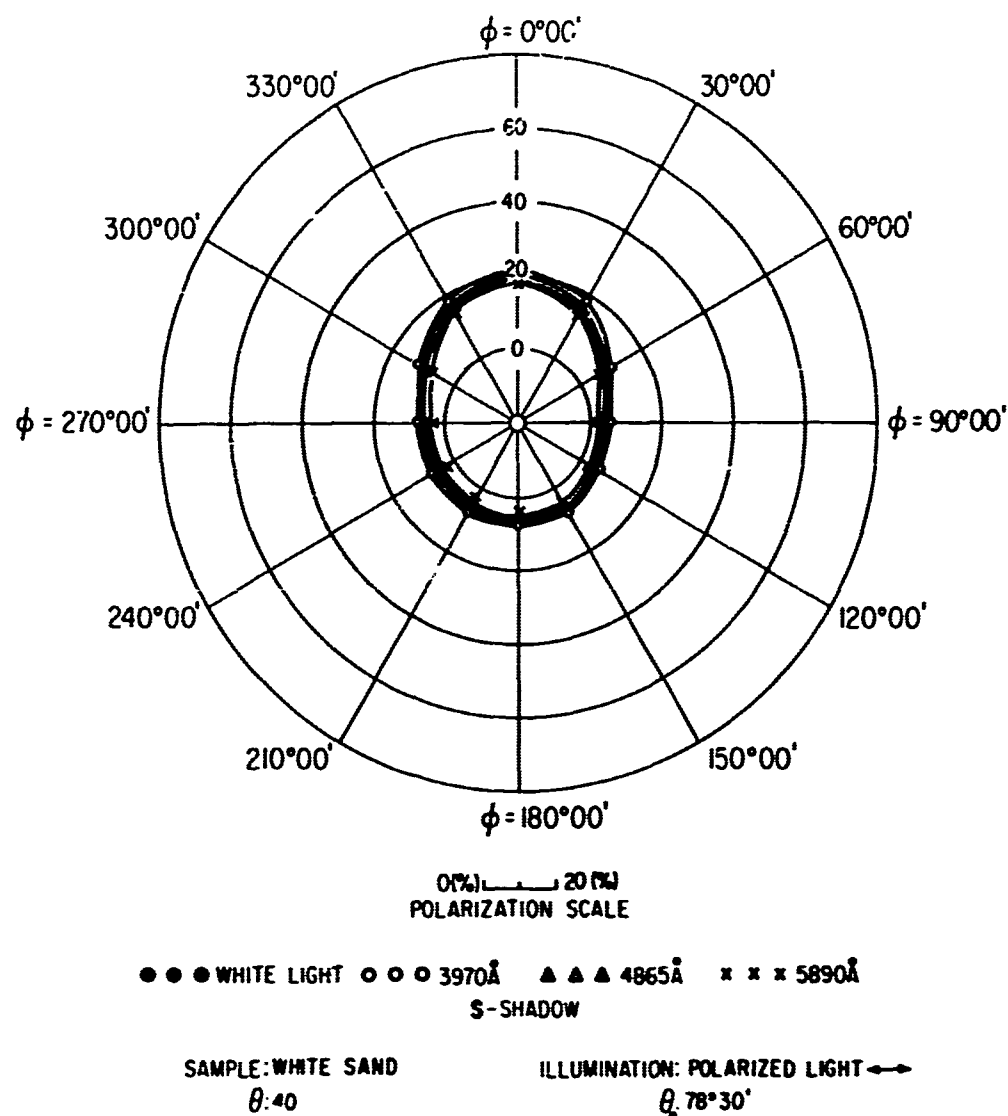


FIG 141 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 8.30 + 6.21 \cos \varphi + 4.22 \cos 2\varphi + 0.95 \cos 3\varphi - 0.02 \cos 4\varphi - 0.11 \cos 5\varphi \\
 & + 0.30 \cos 6\varphi - 1.13 \sin \varphi - 0.65 \sin 2\varphi + 0.22 \sin 3\varphi - 0.19 \sin 4\varphi - 0.15 \sin 5\varphi
 \end{aligned}$$

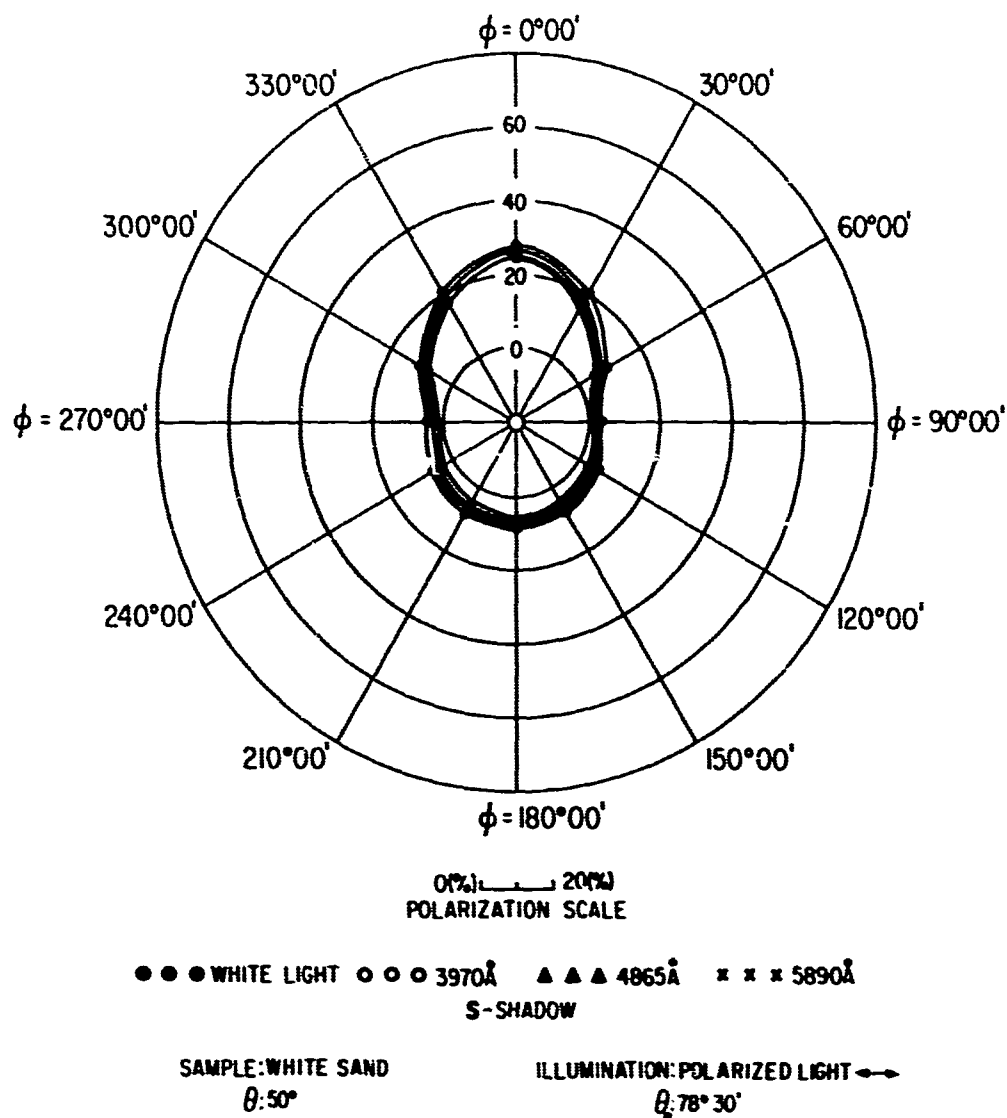


FIG.142 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 9.32 + 7.48 \cos \varphi + 6.37 \cos 2\varphi + 2.08 \cos 3\varphi + 0.75 \cos 4\varphi + 0.24 \cos 5\varphi \\
 & + 0.72 \cos 6\varphi - 0.86 \sin \varphi - 0.84 \sin 2\varphi - 0.27 \sin 3\varphi - 0.12 \sin 4\varphi + 0.15 \sin 5\varphi
 \end{aligned}$$

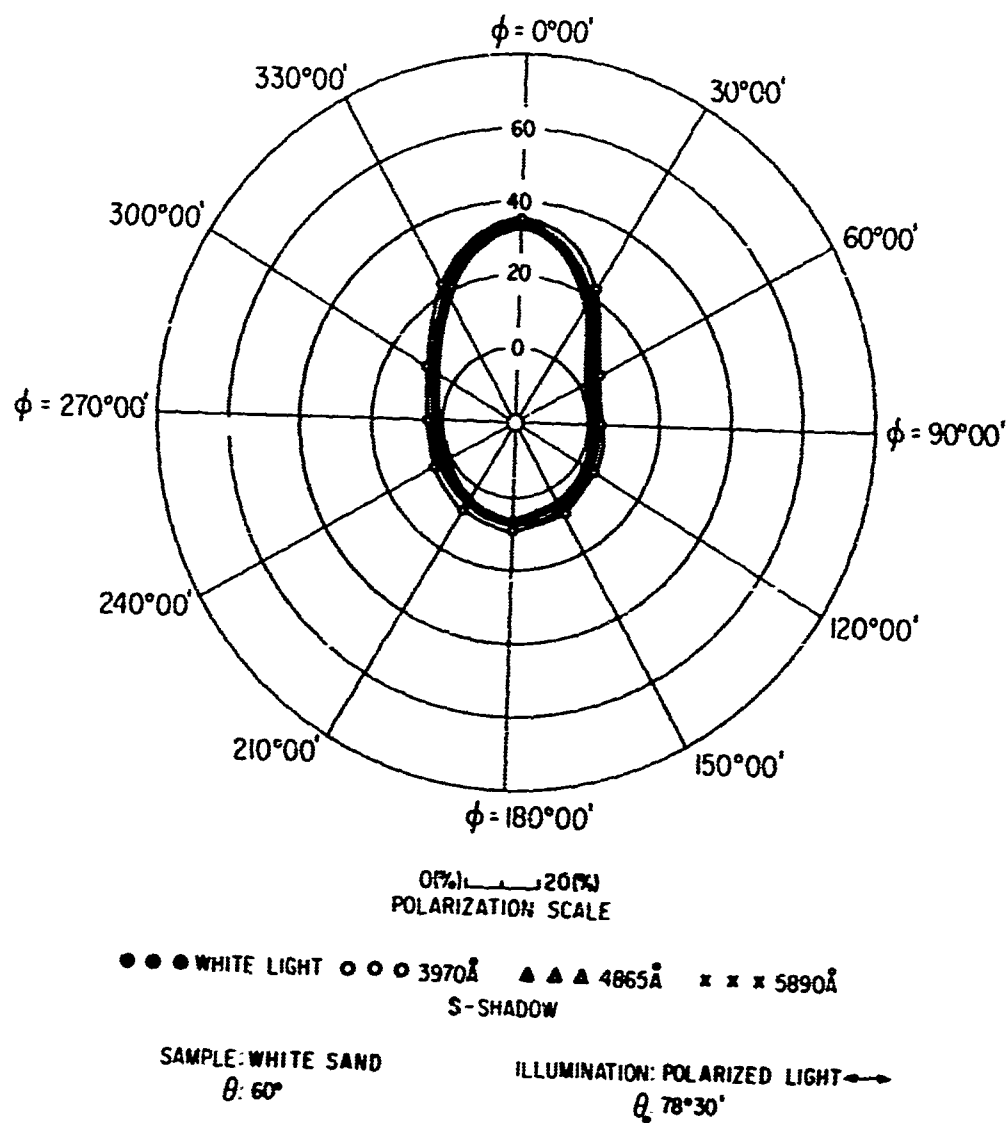


FIG.143 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 8.59 + 8.73 \cos \phi + 8.62 \cos 2\phi + 3.82 \cos 3\phi + 2.12 \cos 4\phi + 1.05 \cos 5\phi \\
 & + 1.30 \cos 6\phi - 0.92 \sin \phi - 0.74 \sin 2\phi - 0.02 \sin 3\phi + 0.10 \sin 4\phi + 0.15 \sin 5\phi
 \end{aligned}$$

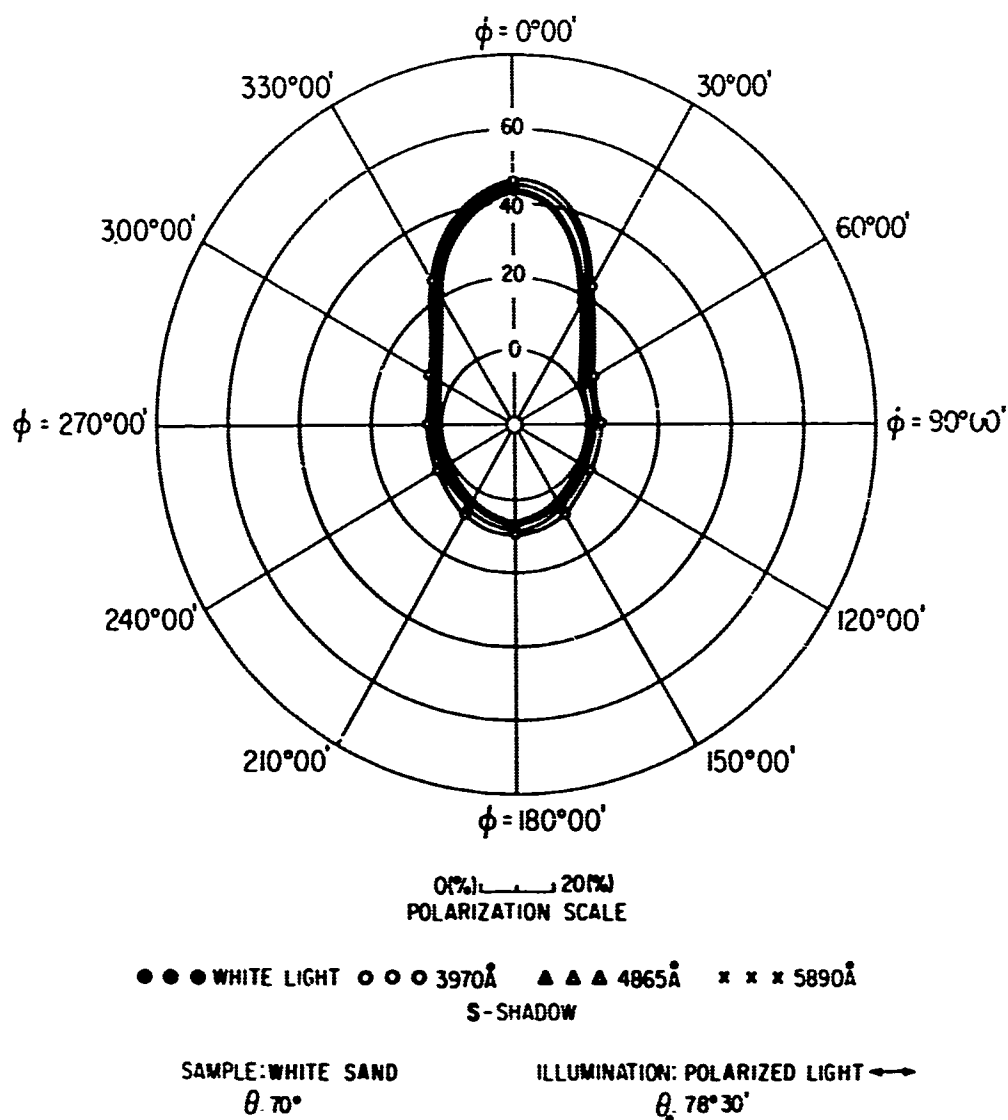
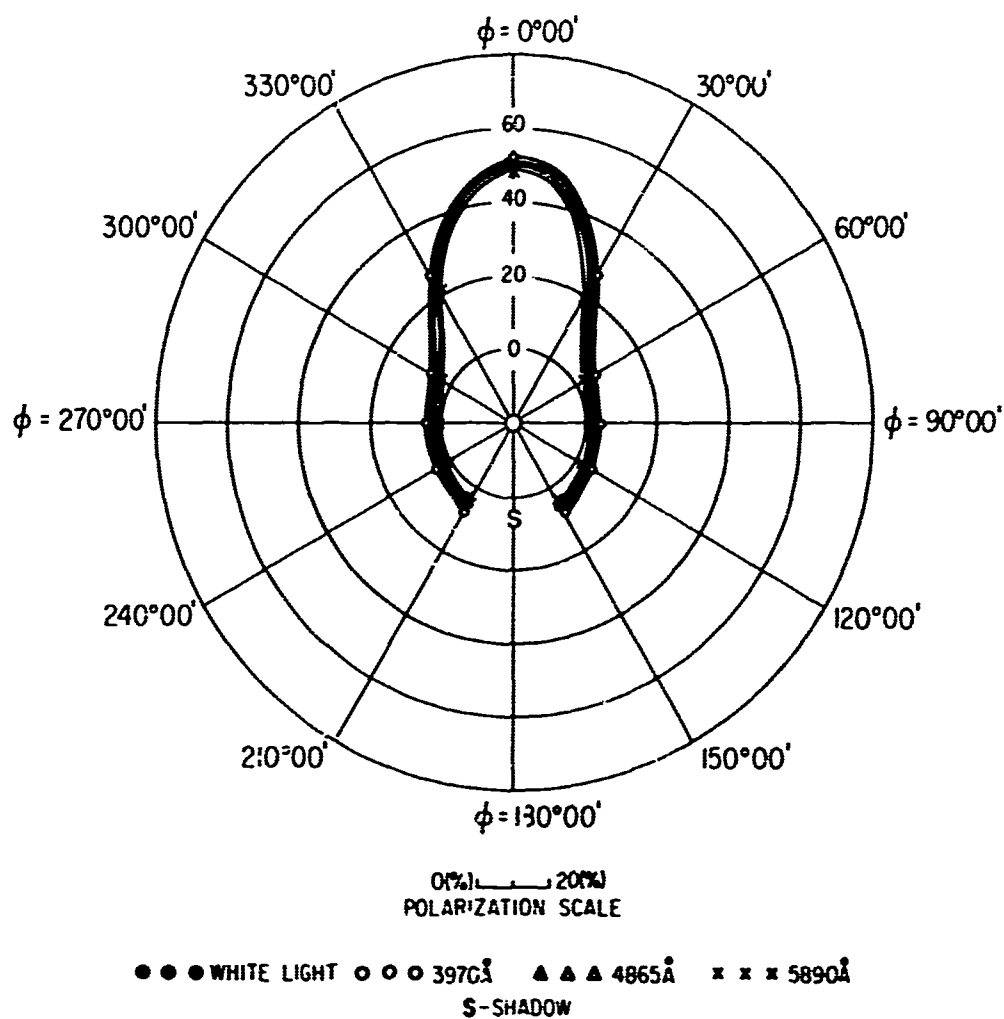


FIG 144 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 9.24 + 10.76 \cos \phi + 11.24 \cos 2\phi + 5.62 \cos 3\phi + 4.18 \cos 4\phi + 1.82 \cos 5\phi \\
 & + 1.62 \cos 6\phi - 1.15 \sin \phi - 1.02 \sin 2\phi - 0.27 \sin 3\phi - 0.13 \sin 4\phi - 0.04 \sin 5\phi
 \end{aligned}$$



SAMPLE: WHITE SAND
 $\theta 75^{\circ}$

ILLUMINATION: POLARIZED LIGHT \longleftrightarrow
 $\theta 78^{\circ}30'$

FIG. 145 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 10.57 + 12.21 \cos \phi + 11.73 \cos 2\phi + 7.10 \cos 3\phi + 4.32 \cos 4\phi + 2.94 \cos 5\phi \\
 & + 1.38 \cos 6\phi - 0.68 \sin \phi - 0.66 \sin 2\phi - 0.82 \sin 3\phi - 0.46 \sin 4\phi - 0.24 \sin 5\phi
 \end{aligned}$$

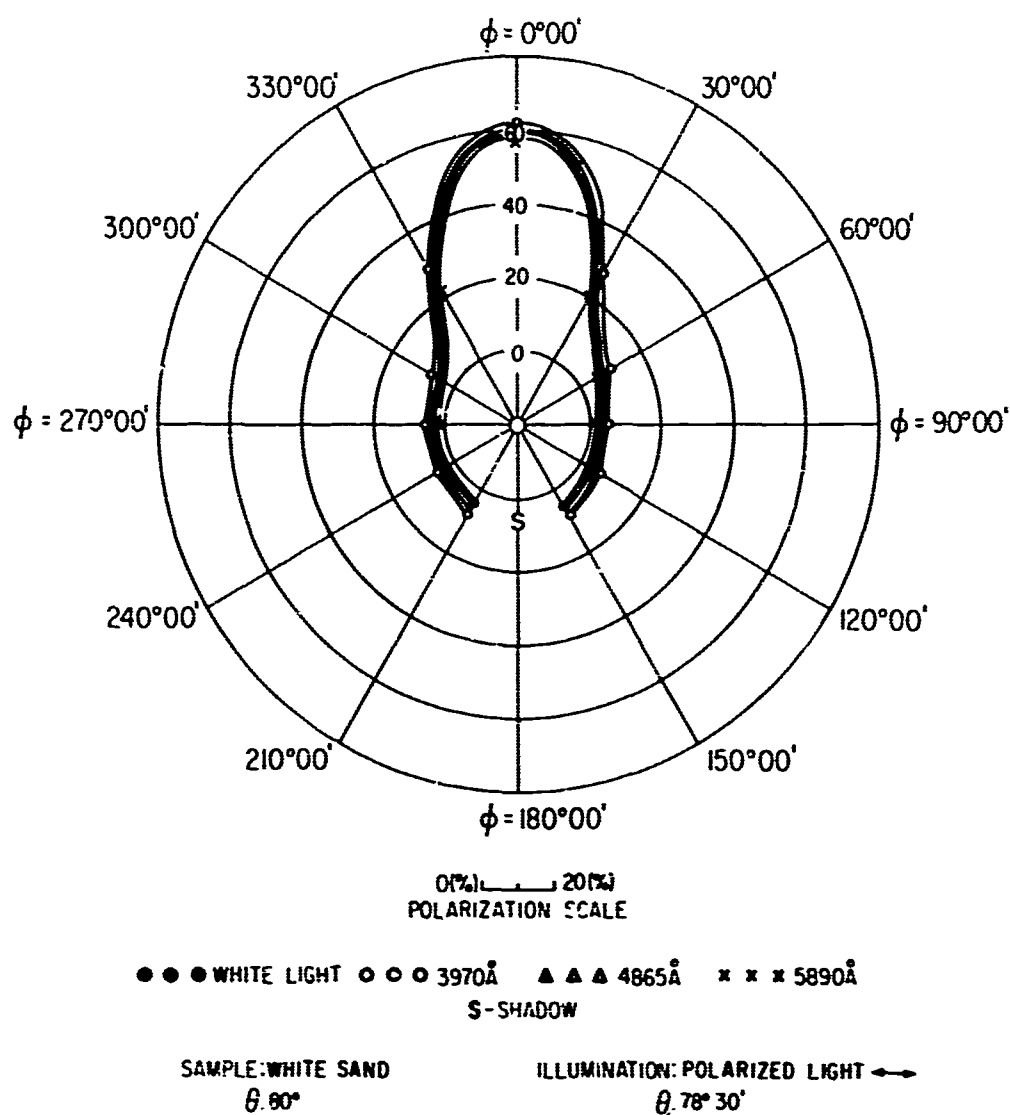


FIG 146 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 11.98 + 15.08 \cos \varphi + 12.06 \cos 2\varphi + 8.08 \cos 3\varphi + 5.36 \cos 4\varphi + 4.08 \cos 5\varphi \\
 & + 3.40 \cos 6\varphi - 0.05 \sin \varphi - 0.04 \sin 2\varphi - 0.12 \sin 3\varphi - 0.85 \sin 4\varphi - 0.57 \sin 5\varphi
 \end{aligned}$$

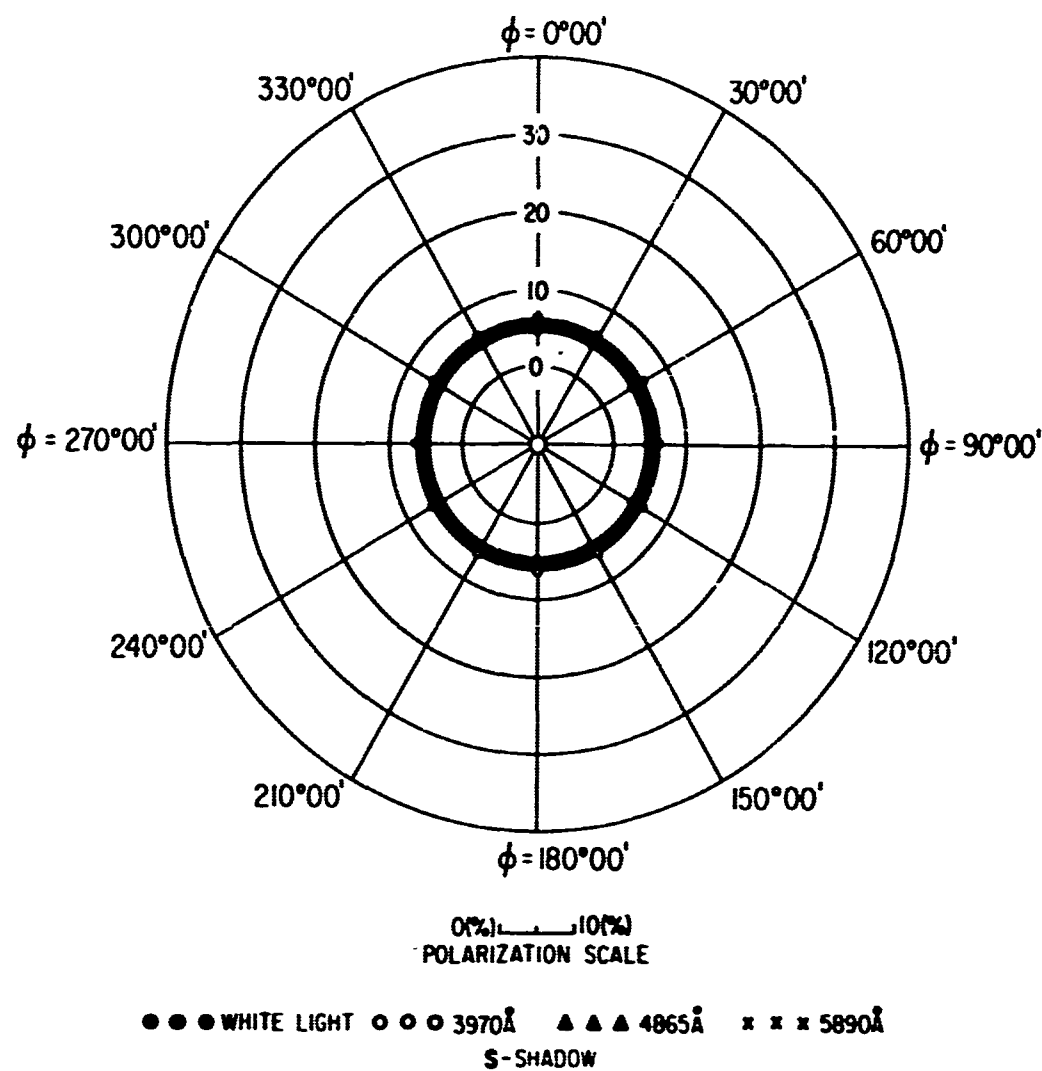
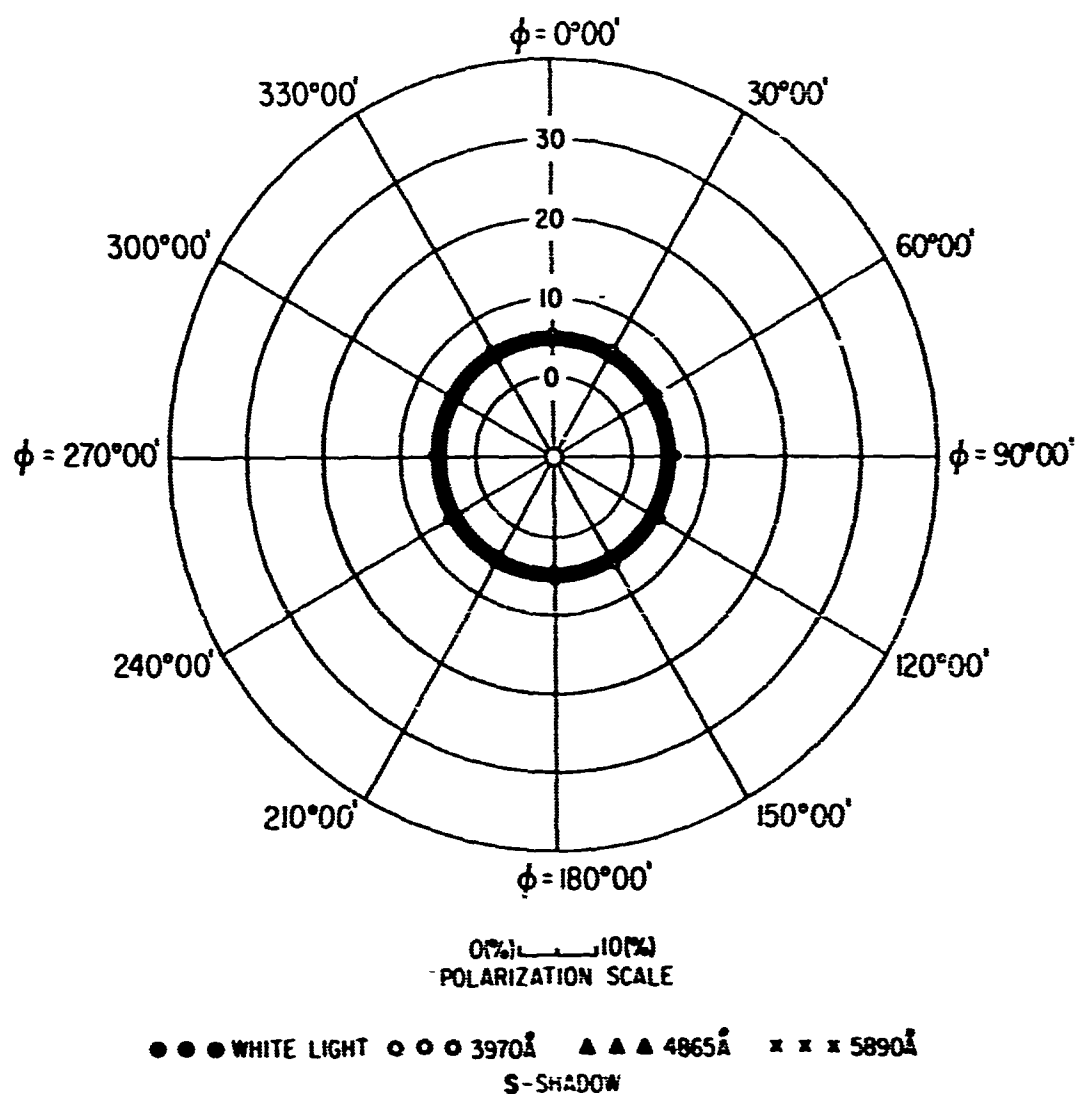


FIG 147 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 5.00 + 0.09 \cos \varphi - 0.08 \cos 2\varphi - 0.10 \cos 3\varphi + 0.10 \cos 4\varphi + 0.06 \cos 5\varphi \\
 & - 0.13 \cos 6\varphi + 0.12 \sin \varphi + 0.03 \sin 2\varphi - 0.07 \sin 3\varphi - 0.06 \sin 4\varphi - 0.14 \sin 5\varphi
 \end{aligned}$$



SAMPLE: WHITE SAND
 $\theta: 20^\circ$

ILLUMINATION: POLARIZED LIGHT \uparrow
 $\theta: 0^\circ$

FIG. 148 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 4.76 + 0.18 \cos \phi - 0.15 \cos 2\phi - 0.07 \cos 3\phi + 0.02 \cos 4\phi - 0.16 \cos 5\phi \\
 & - 0.25 \cos 6\phi - 0.08 \sin \phi - 0.03 \sin 2\phi - 0.05 \sin 3\phi - 0.03 \sin 4\phi - 0.02 \sin 5\phi
 \end{aligned}$$

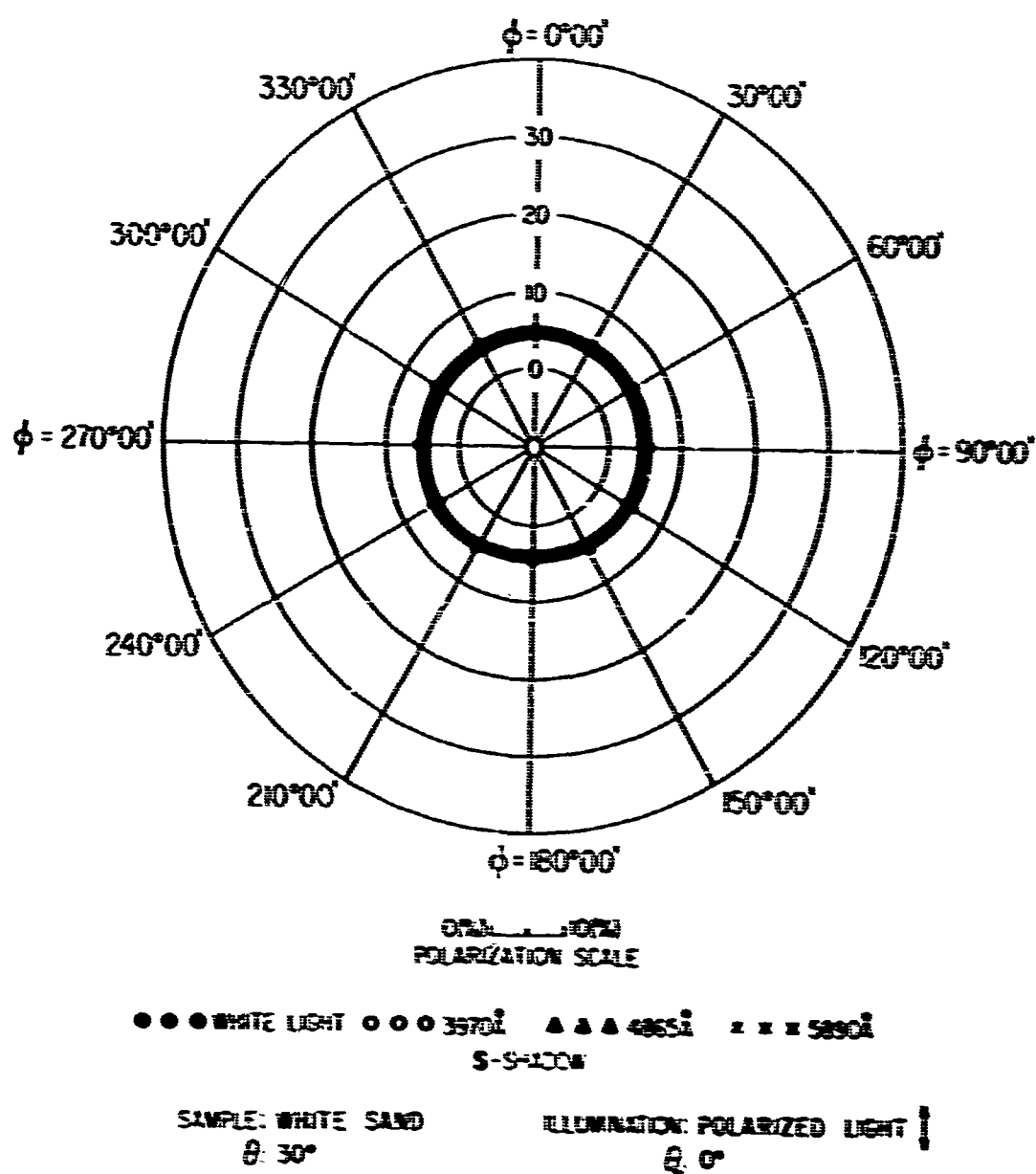


FIG 149 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 4.28 - 0.01 \cos \phi - 0.30 \cos 2\phi + 0.03 \cos 3\phi - 0.15 \cos 4\phi + 0.02 \cos 5\phi \\ + 0.05 \cos 6\phi - 0.06 \sin \phi + 0.09 \sin 2\phi - 0.02 \sin 3\phi - 0.06 \sin 4\phi - 0.08 \sin 5\phi$$

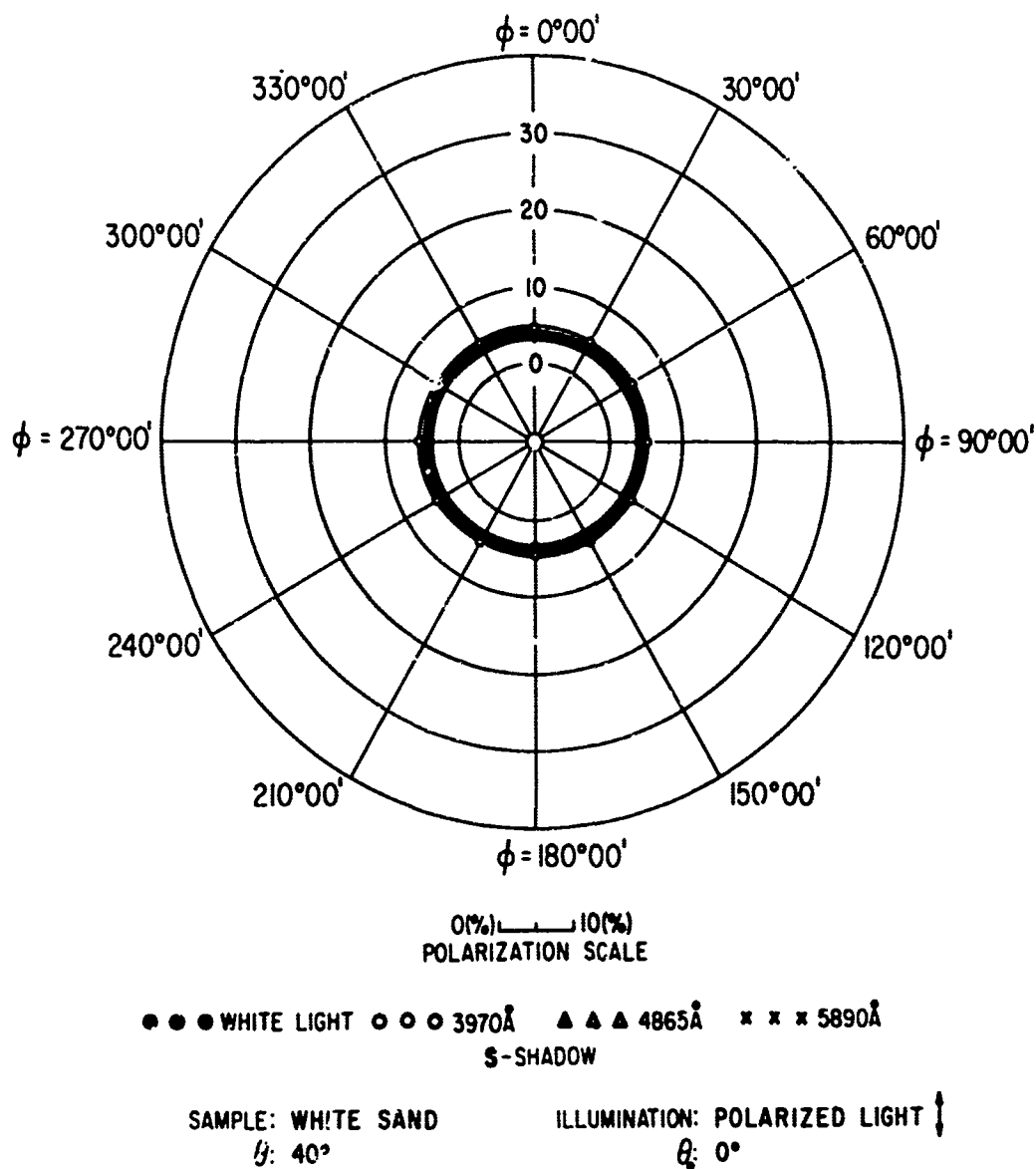


FIG. 150 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 3.96 - 0.00 \cos \varphi - 0.53 \cos 2\varphi - 0.07 \cos 3\varphi + 0.12 \cos 4\varphi - 0.08 \cos 5\varphi \\
 & + 0.02 \cos 6\varphi - 0.01 \sin \varphi + 0.09 \sin 2\varphi - 0.05 \sin 3\varphi + 0.00 \sin 4\varphi - 0.04 \sin 5\varphi
 \end{aligned}$$

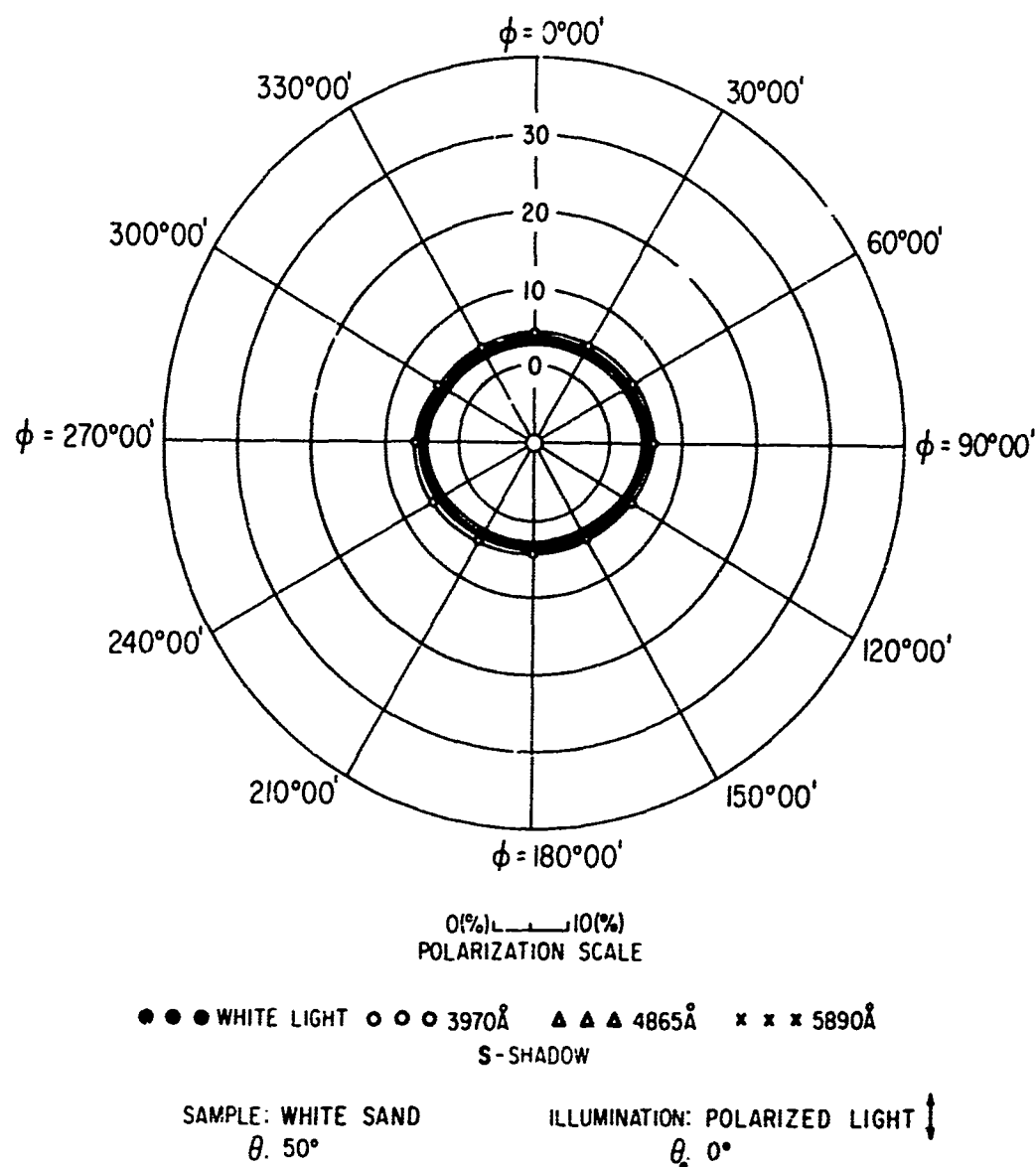


FIG 151 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 3.75 - 0.09 \cos \varphi - 0.77 \cos 2\varphi + 0.05 \cos 3\varphi + 0.30 \cos 4\varphi - 0.09 \cos 5\varphi \\ + 0.10 \cos 6\varphi - 0.05 \sin \varphi - 0.17 \sin 2\varphi - 0.22 \sin 3\varphi + 0.00 \sin 4\varphi - 0.12 \sin 5\varphi$$

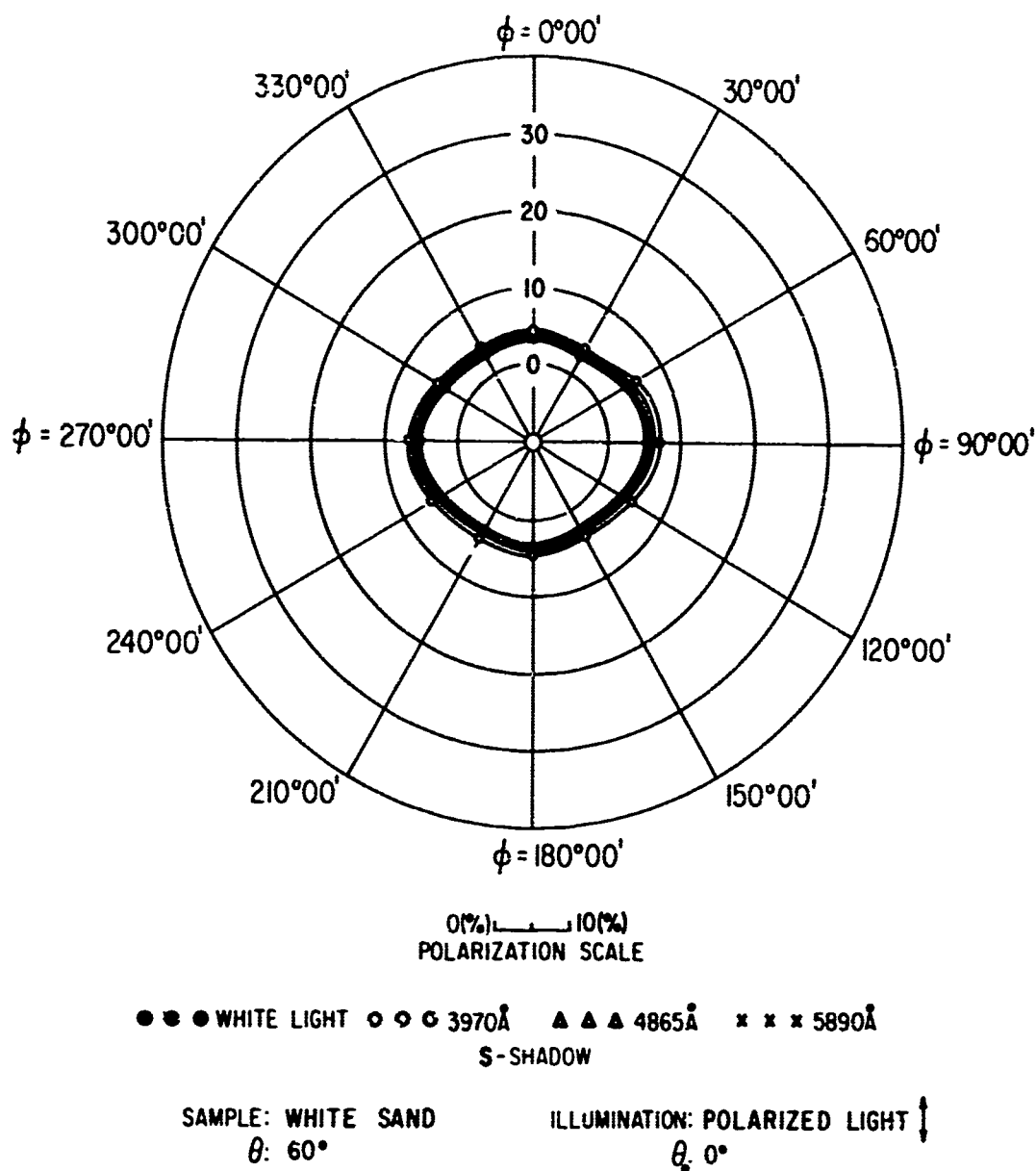
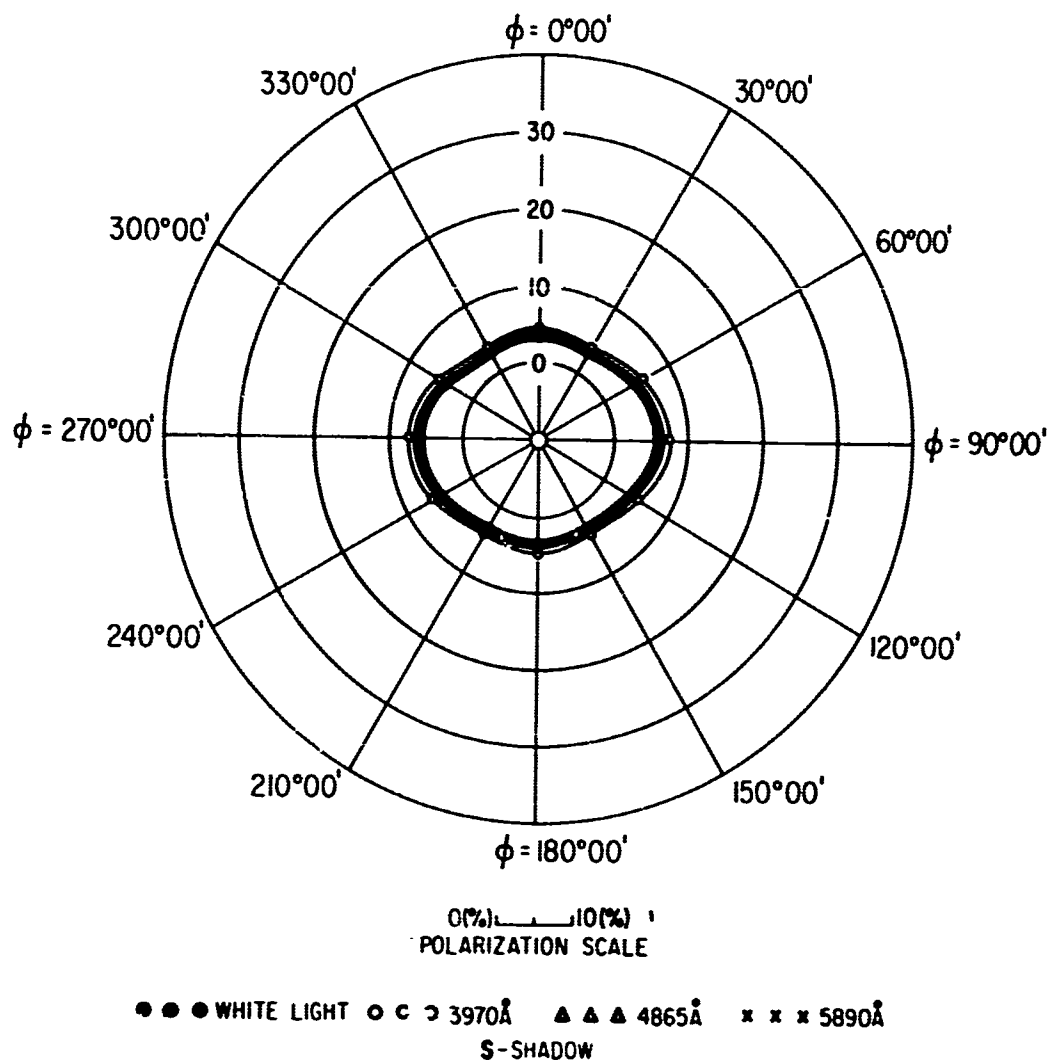


FIG. 152 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 3.63 + 0.16 \cos \phi - 1.10 \cos 2\phi + 0.00 \cos 3\phi + 0.47 \cos 4\phi - 0.21 \cos 5\phi \\
 & + 0.20 \cos 6\phi - 0.09 \sin \phi + 0.23 \sin 2\phi - 0.20 \sin 3\phi + 0.00 \sin 4\phi - 0.21 \sin 5\phi
 \end{aligned}$$



SAMPLE: WHITE SAND
 $\theta: 70^\circ$

ILLUMINATION: POLARIZED LIGHT ↑
 $\theta_i: 0^\circ$

FIG 153 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 3.98 - 0.02 \cos \phi - 1.36 \cos 2\phi + 0.00 \cos 3\phi - 0.68 \cos 4\phi - 0.02 \cos 5\phi \\
 & + 0.22 \cos 6\phi + 0.09 \sin \phi + 0.36 \sin 2\phi + 0.05 \sin 3\phi - 0.19 \sin 4\phi + 0.11 \sin 5\phi
 \end{aligned}$$

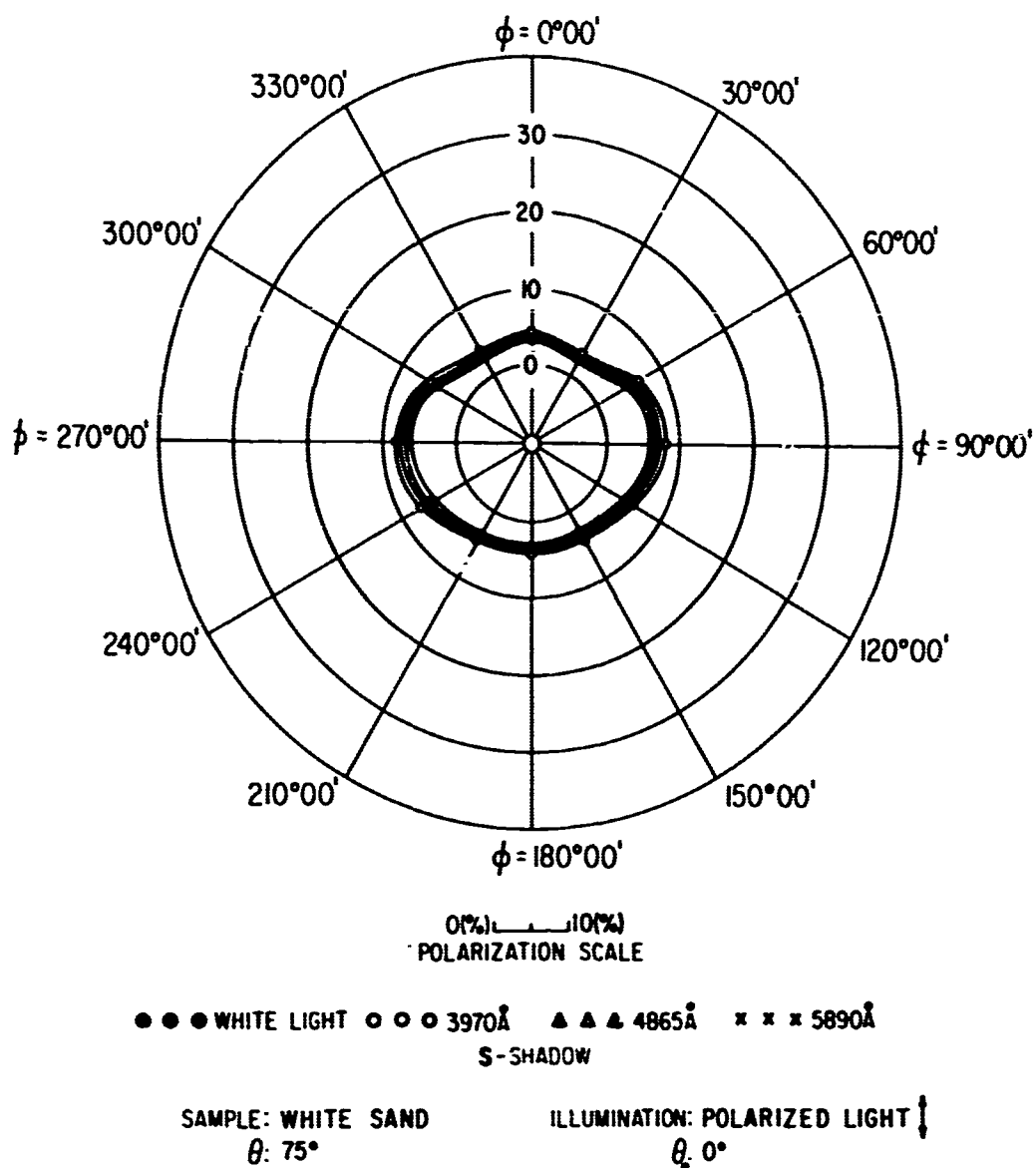


FIG. 154 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 4.28 - 0.18 \cos \varphi - 1.47 \cos 2\varphi - 0.20 \cos 3\varphi + 0.97 \cos 4\varphi + 0.13 \cos 5\varphi \\
 & + 0.17 \cos 6\varphi - 0.06 \sin \varphi + 0.52 \sin 2\varphi - 0.07 \sin 3\varphi - 0.38 \sin 4\varphi + 0.14 \sin 5\varphi
 \end{aligned}$$

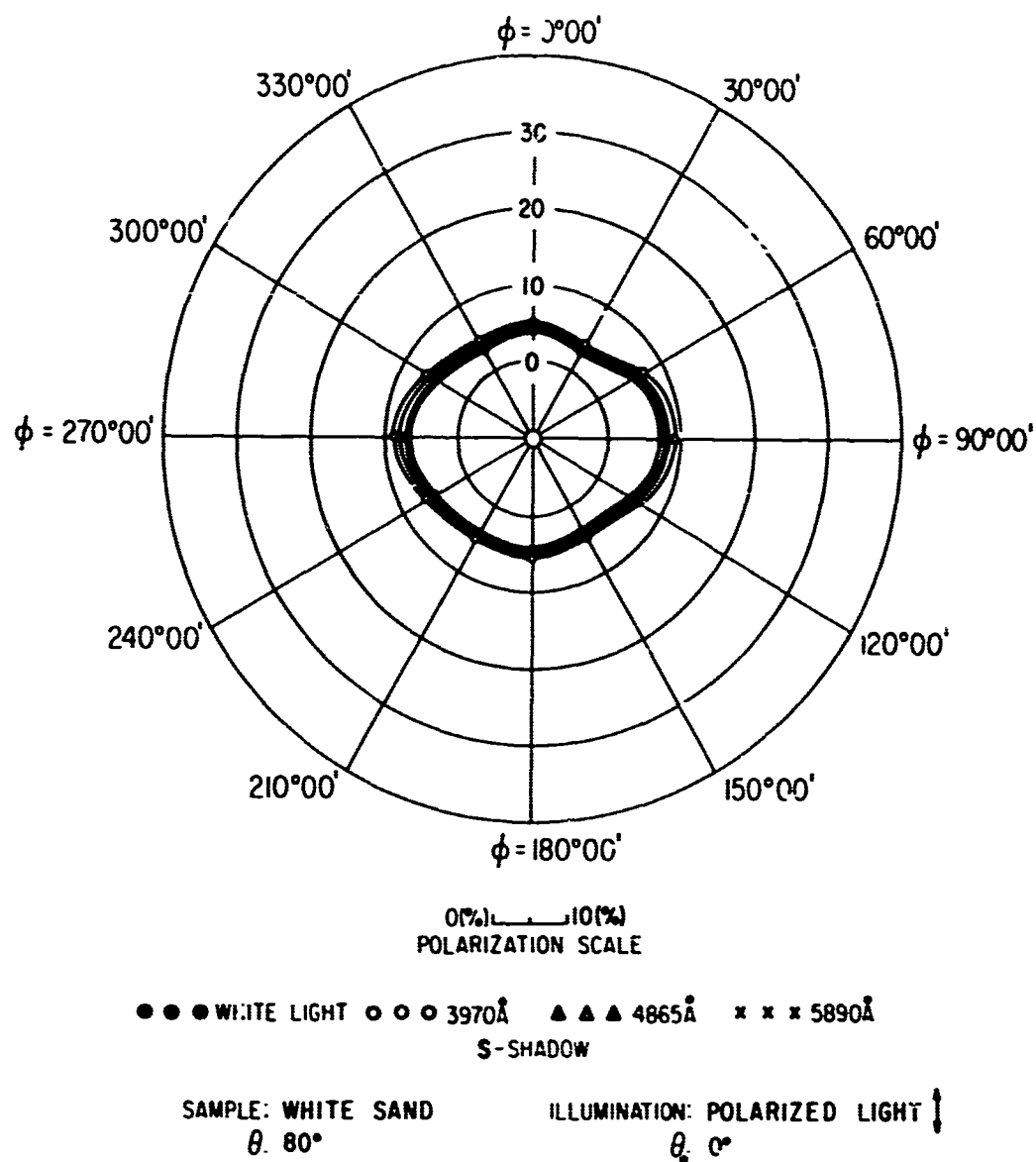


FIG 155 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 4.90 - 0.39 \cos \varphi - 1.81 \cos 2\varphi + 0.12 \cos 3\varphi + 0.98 \cos 4\varphi - 0.08 \cos 5\varphi \\
 & + 0.57 \cos 6\varphi + 0.07 \sin \varphi + 0.30 \sin 2\varphi - 0.12 \sin 3\varphi - 0.16 \sin 4\varphi + 0.01 \sin 5\varphi
 \end{aligned}$$

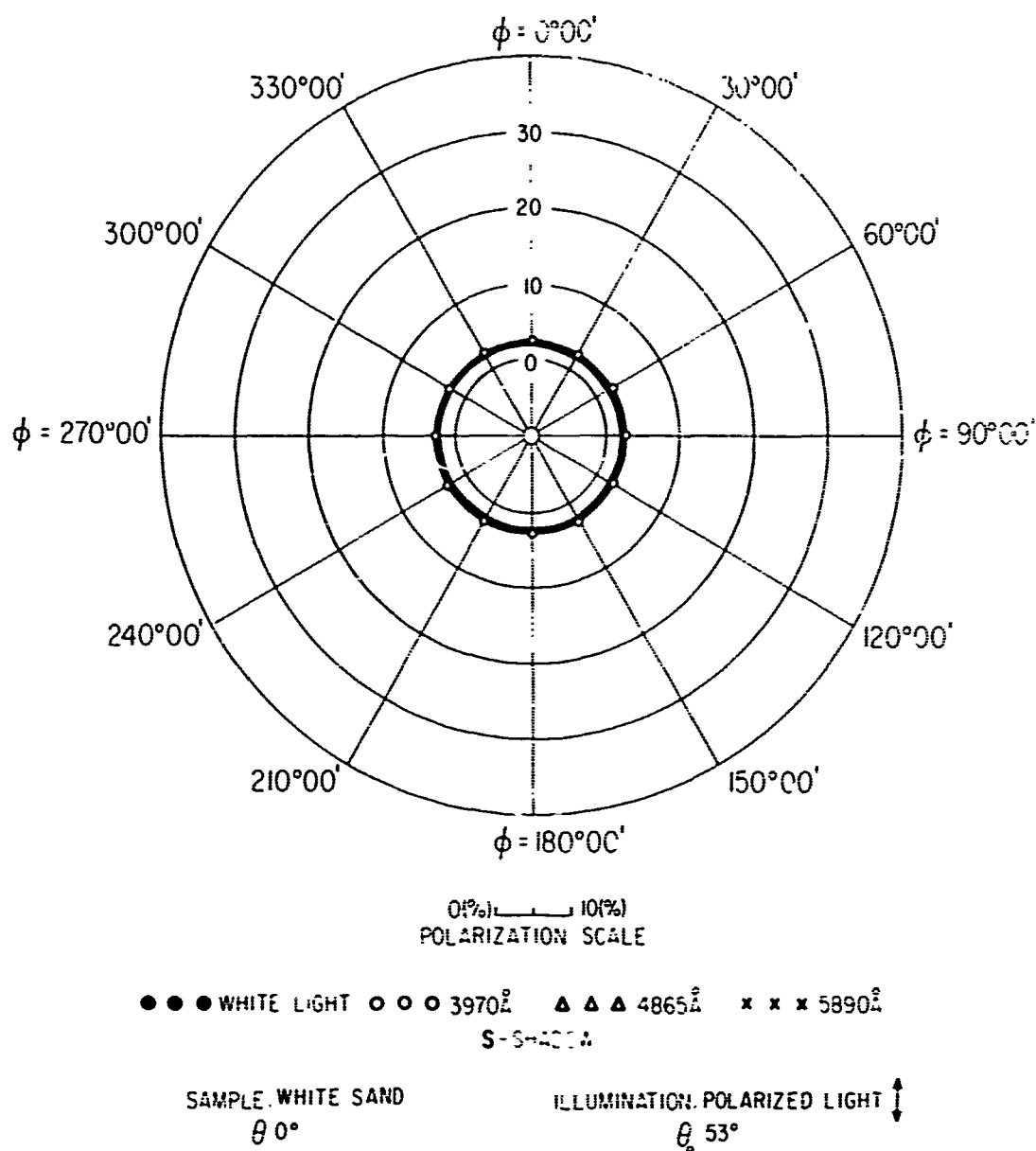


FIG 156 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

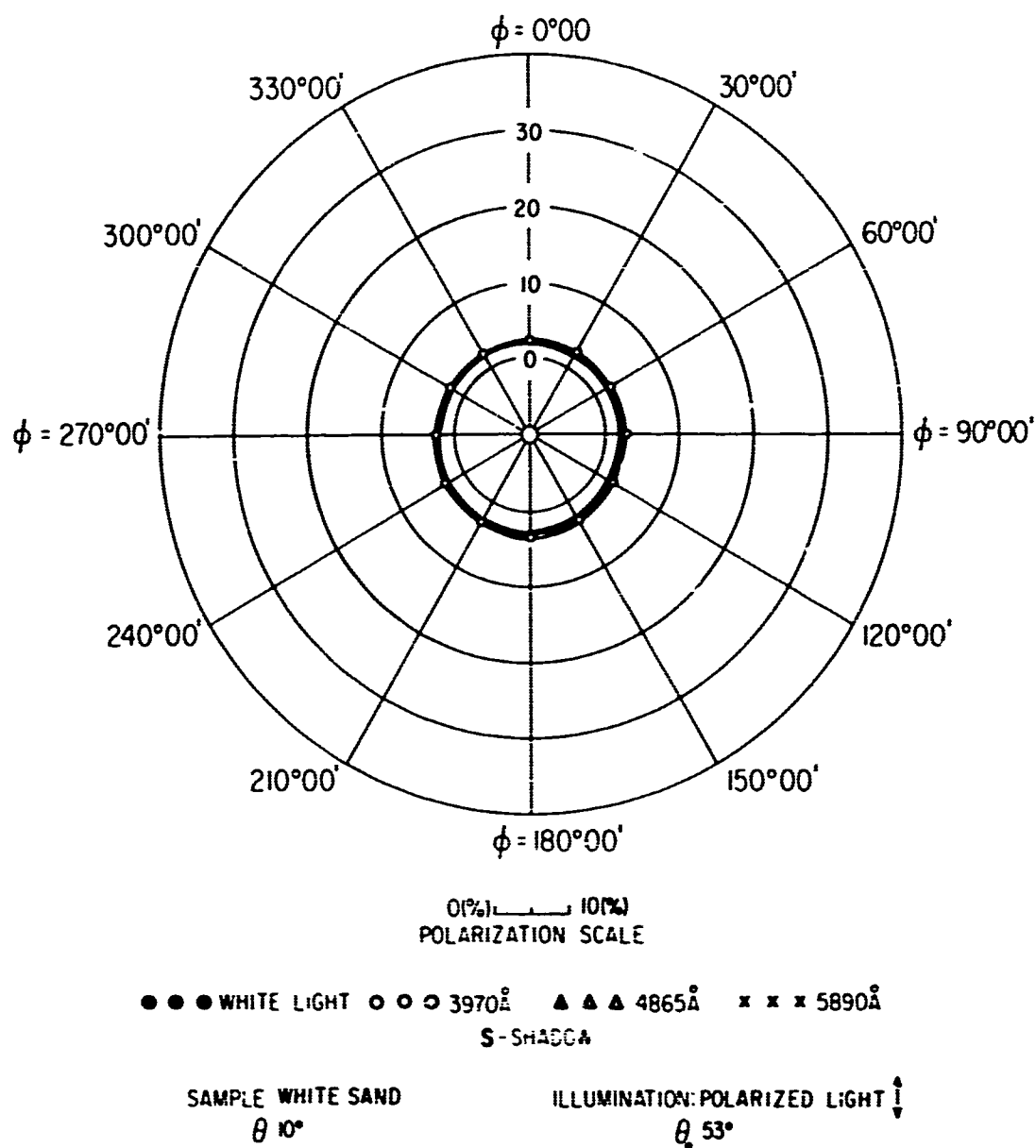


FIG 157 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 2.71 - 0.49 \cos \phi + 0.02 \cos 2\phi + 0.12 \cos 3\phi + 0.12 \cos 4\phi + 0.02 \cos 5\phi \\
 & + 0.02 \cos 6\phi - 0.12 \sin \phi + 0.12 \sin 2\phi - 0.13 \sin 3\phi + 0.00 \sin 4\phi - 0.01 \sin 5\phi
 \end{aligned}$$

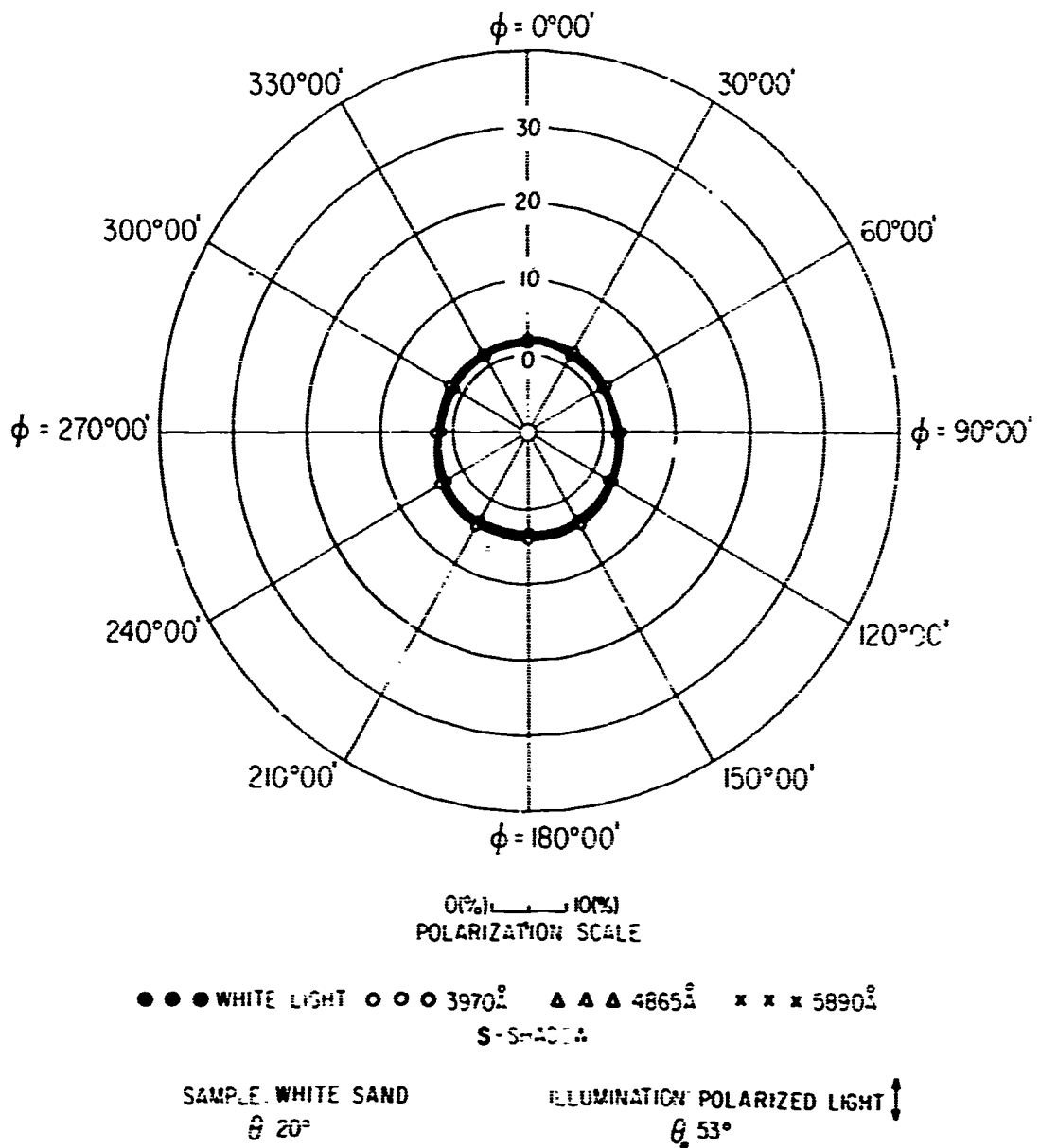
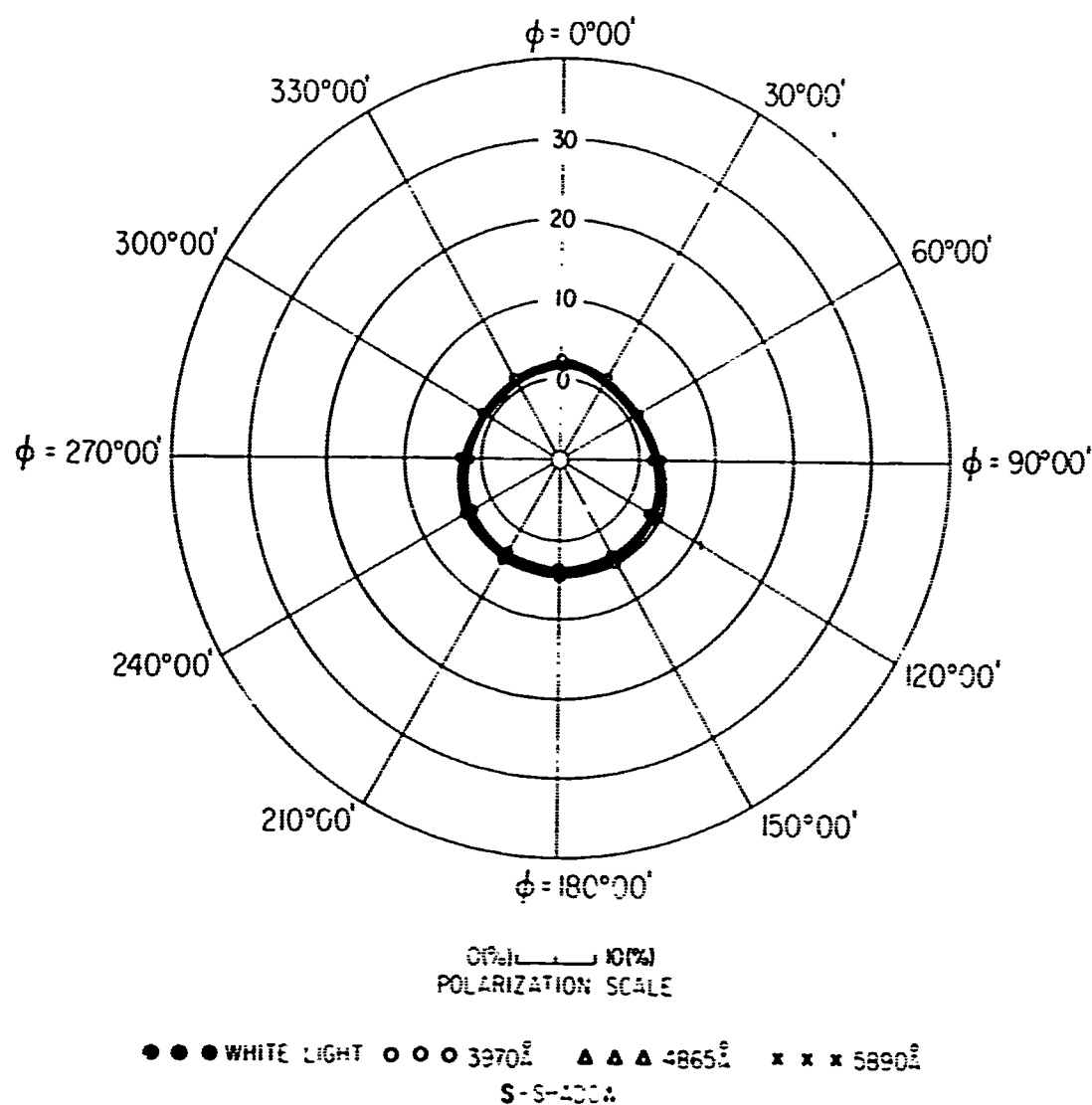


FIG 158 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 2.81 - 0.89 \cos \phi + 0.12 \cos 2\phi + 0.03 \cos 3\phi + 0.04 \cos 4\phi - 0.05 \cos 5\phi \\
 & + 0.05 \cos 6\phi - 0.02 \sin \phi + 0.03 \sin 2\phi + 0.06 \sin 3\phi - 0.00 \sin 4\phi + 0.01 \sin 5\phi
 \end{aligned}$$



SAMPLE WHITE SAND
 θ 30°

ILLUMINATION POLARIZED LIGHT ↑
 θ_0 53°

FIG 159 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 3.02 - 1.64 \cos \phi + 0.45 \cos 2\phi + 0.30 \cos 3\phi + 0.15 \cos 4\phi - 0.08 \cos 5\phi \\ - 0.05 \cos 6\phi + 0.00 \sin \phi - 0.12 \sin 2\phi - 0.15 \sin 3\phi - 0.12 \sin 4\phi + 0.00 \sin 5\phi$$

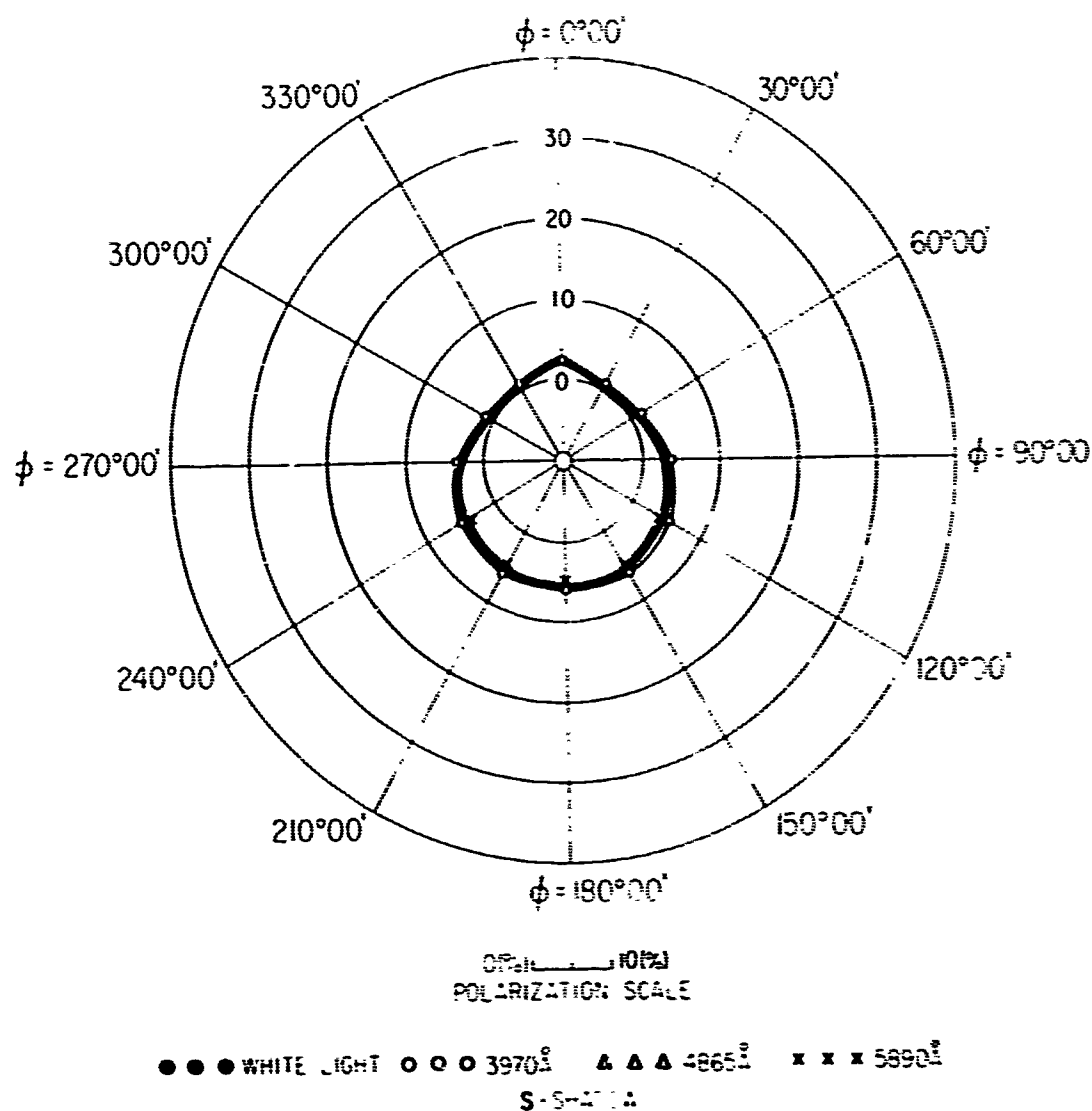


FIG 160 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 3.25 - 2.29 \cos \phi + 0.15 \cos 2\phi + 0.58 \cos 3\phi + 0.55 \cos 4\phi + 0.25 \cos 5\phi \\
 & + 0.20 \cos 6\phi + 0.21 \sin \phi + 0.60 \sin 2\phi - 0.18 \sin 3\phi + 0.60 \sin 4\phi - 0.14 \sin 5\phi
 \end{aligned}$$

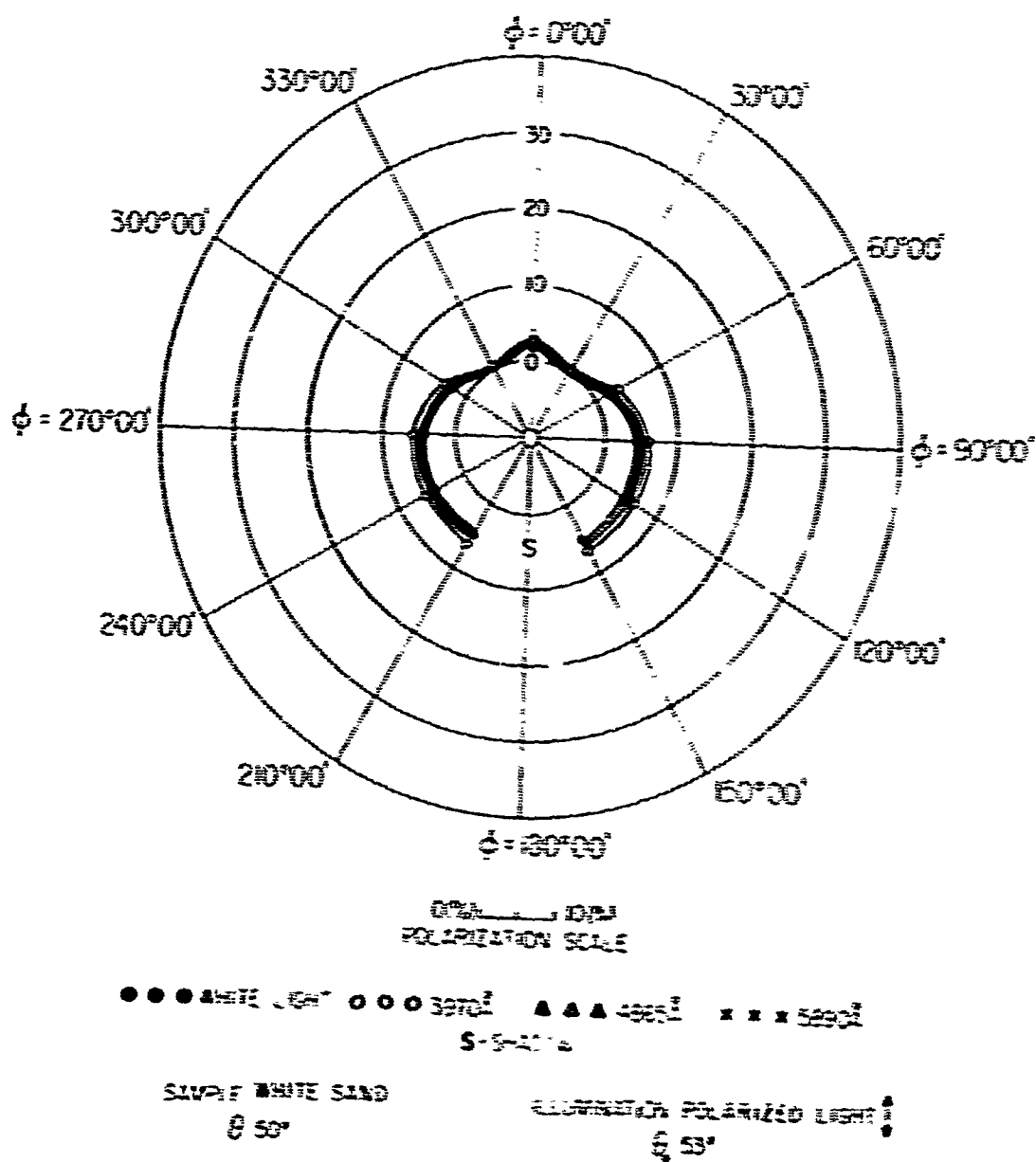


FIG 16: POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 3.83 - 2.55 \cos \phi - 0.30 \cos 2\phi + 0.27 \cos 3\phi + 0.52 \cos 4\phi + 0.54 \cos 5\phi \\ + 0.40 \cos 6\phi + 0.39 \sin \phi + 0.12 \sin 2\phi - 0.17 \sin 3\phi - 0.14 \sin 4\phi - 0.10 \sin 5\phi$$

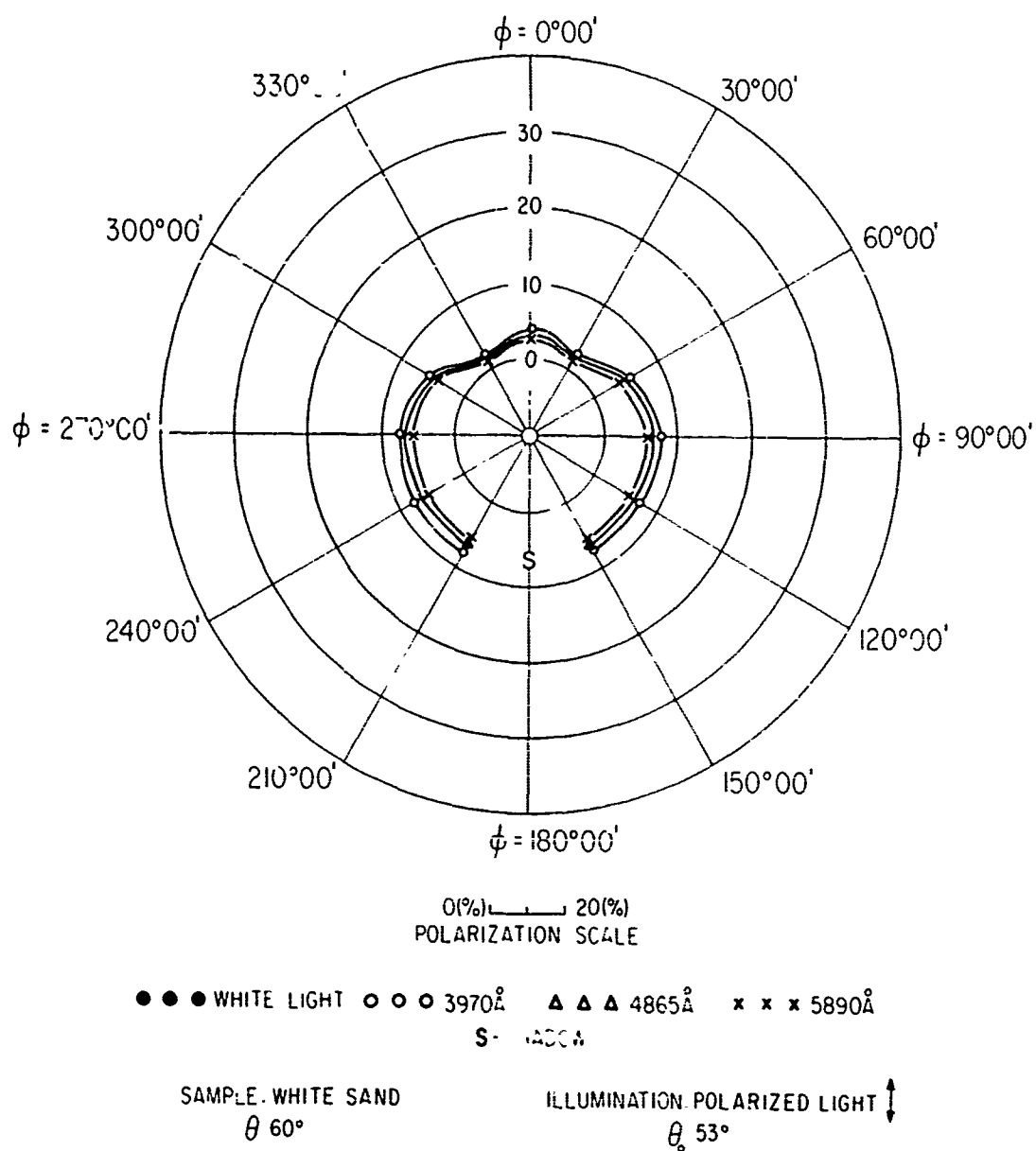
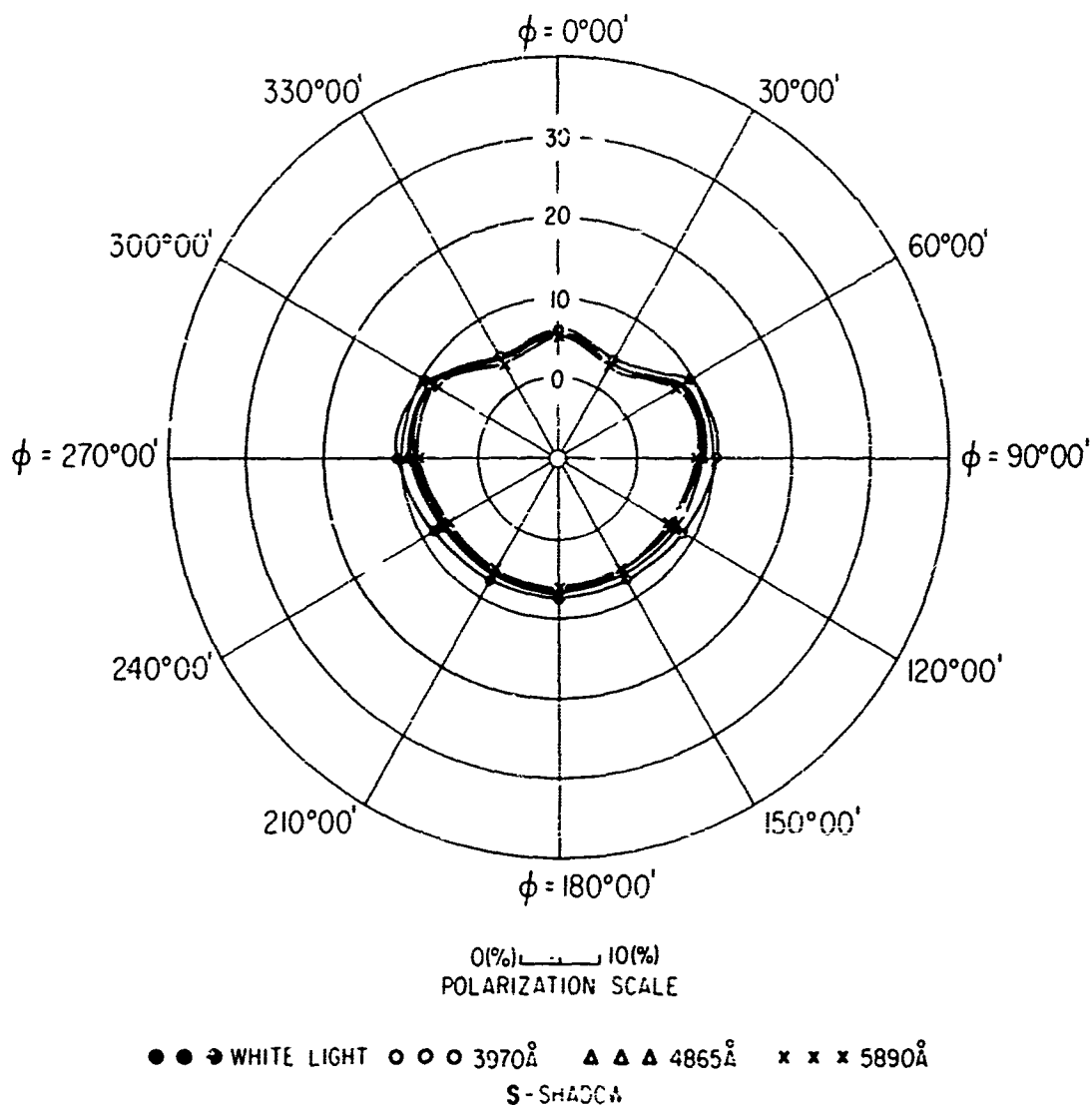


FIG 162 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.08 - 1.95 \cos \phi - 0.74 \cos 2\phi - 0.02 \cos 3\phi + 0.49 \cos 4\phi + 0.47 \cos 5\phi \\
 & + 0.53 \cos 6\phi + 0.38 \sin \phi + 0.30 \sin 2\phi - 0.12 \sin 3\phi + 0.90 \sin 4\phi - 0.05 \sin 5\phi
 \end{aligned}$$



SAMPLE WHITE SAND
 $\theta_0 70^\circ$

ILLUMINATION POLARIZED LIGHT
 $\theta_0 53^\circ$

FIG 163 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 6.65 - 0.78 \cos \phi - 0.92 \cos 2\phi - 0.28 \cos 3\phi + 0.38 \cos 4\phi + 0.26 \cos 5\phi \\
 & + 0.40 \cos 6\phi + 0.68 \sin \phi + 0.42 \sin 2\phi - 0.05 \sin 3\phi - 0.01 \sin 4\phi + 0.12 \sin 5\phi
 \end{aligned}$$

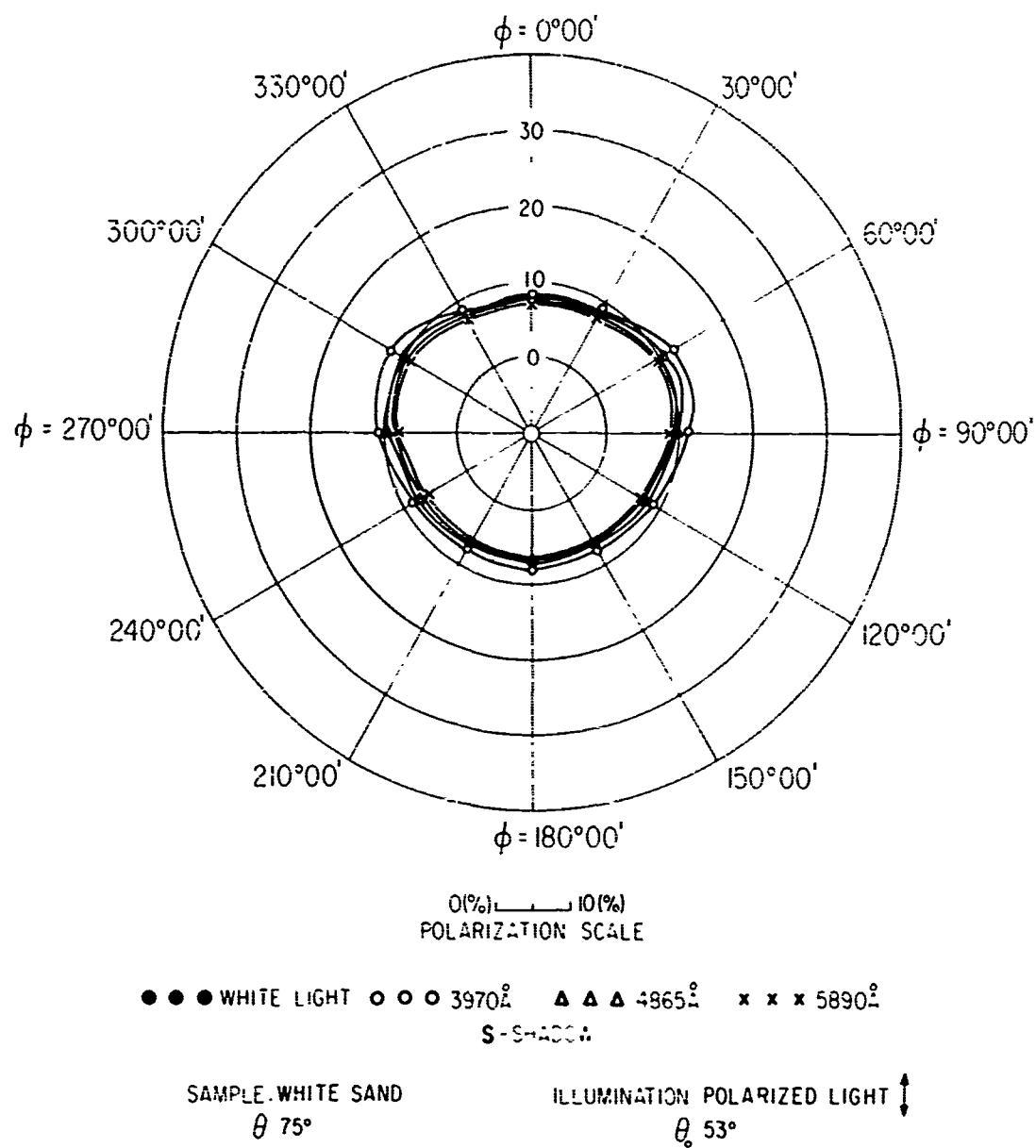


FIG 164 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 7.83 + 0.55 \cos \phi - 0.85 \cos 2\phi - 0.32 \cos 3\phi + 0.17 \cos 4\phi + 0.06 \cos 5\phi \\
 & + 0.50 \cos 6\phi + 0.43 \sin \phi + 0.64 \sin 2\phi + 0.18 \sin 3\phi + 0.03 \sin 4\phi + 0.06 \sin 6\phi
 \end{aligned}$$

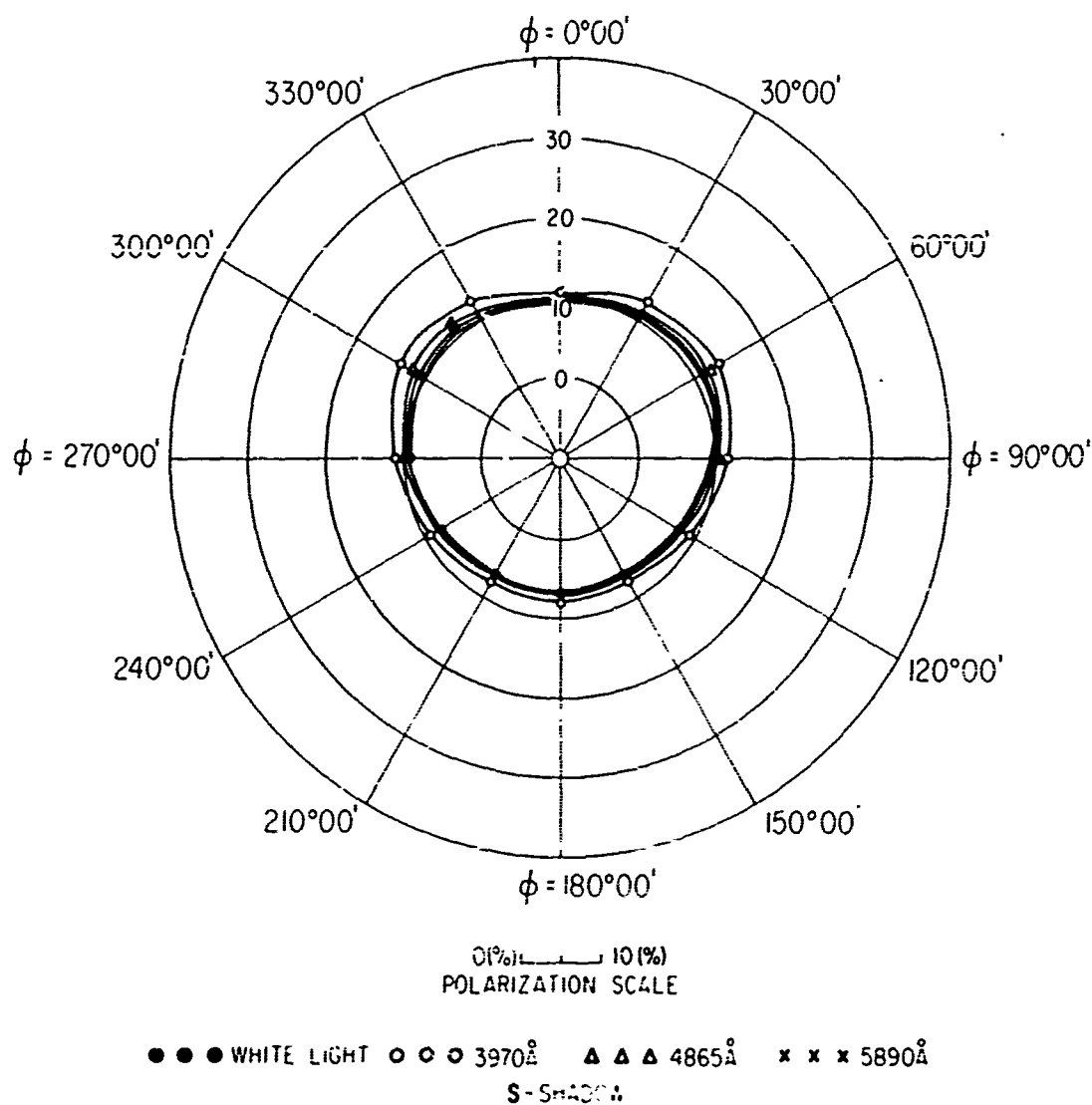


FIG 165 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 9.05 + 1.92 \cos \varphi - 0.65 \cos 2\varphi - 0.68 \cos 3\varphi + 0.10 \cos 4\varphi + 0.16 \cos 5\varphi \\
 & + 0.20 \cos 6\varphi + 0.86 \sin \varphi + 0.57 \sin 2\varphi + 0.18 \sin 3\varphi + 0.09 \sin 4\varphi + 0.02 \sin 5\varphi
 \end{aligned}$$

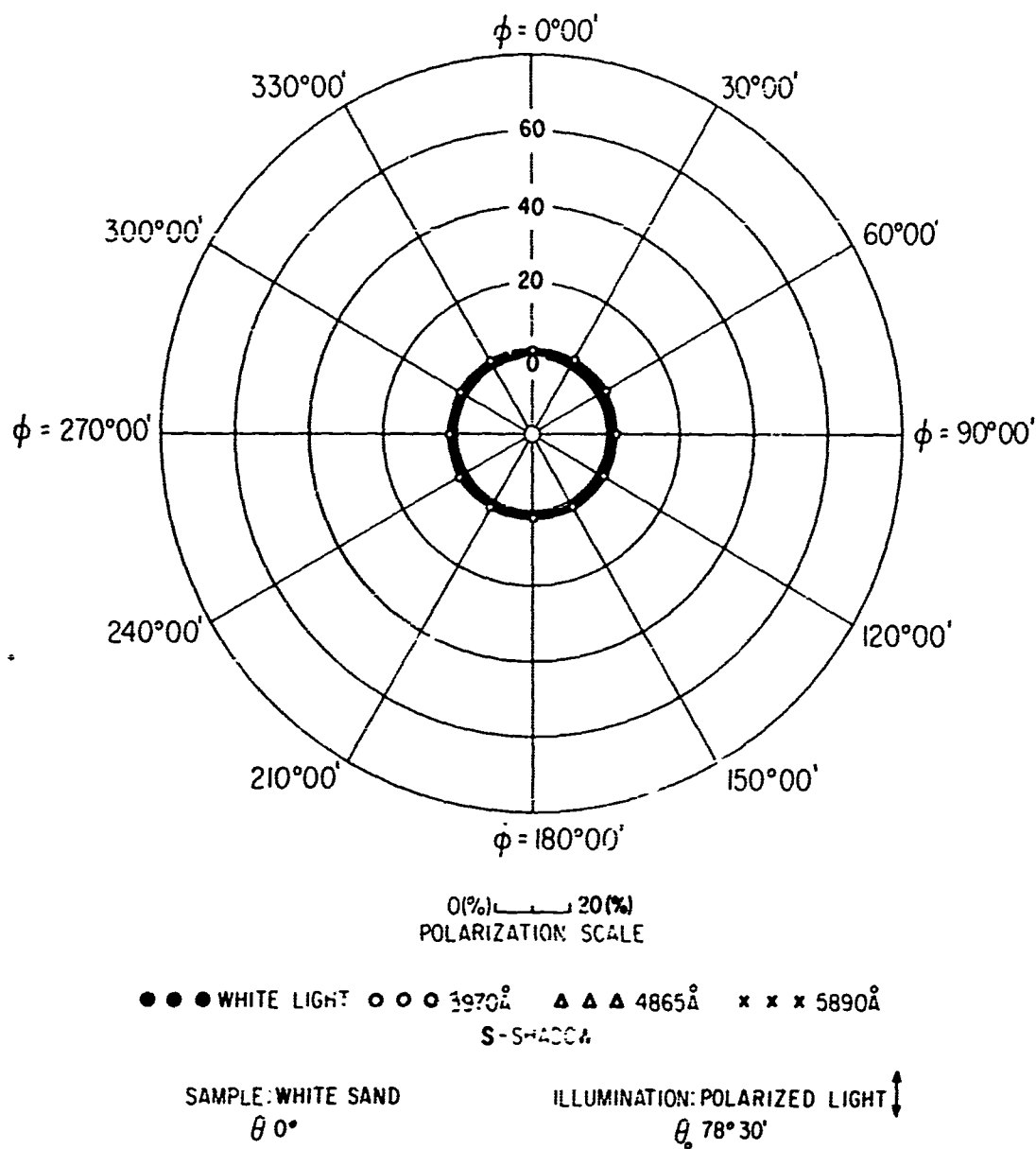
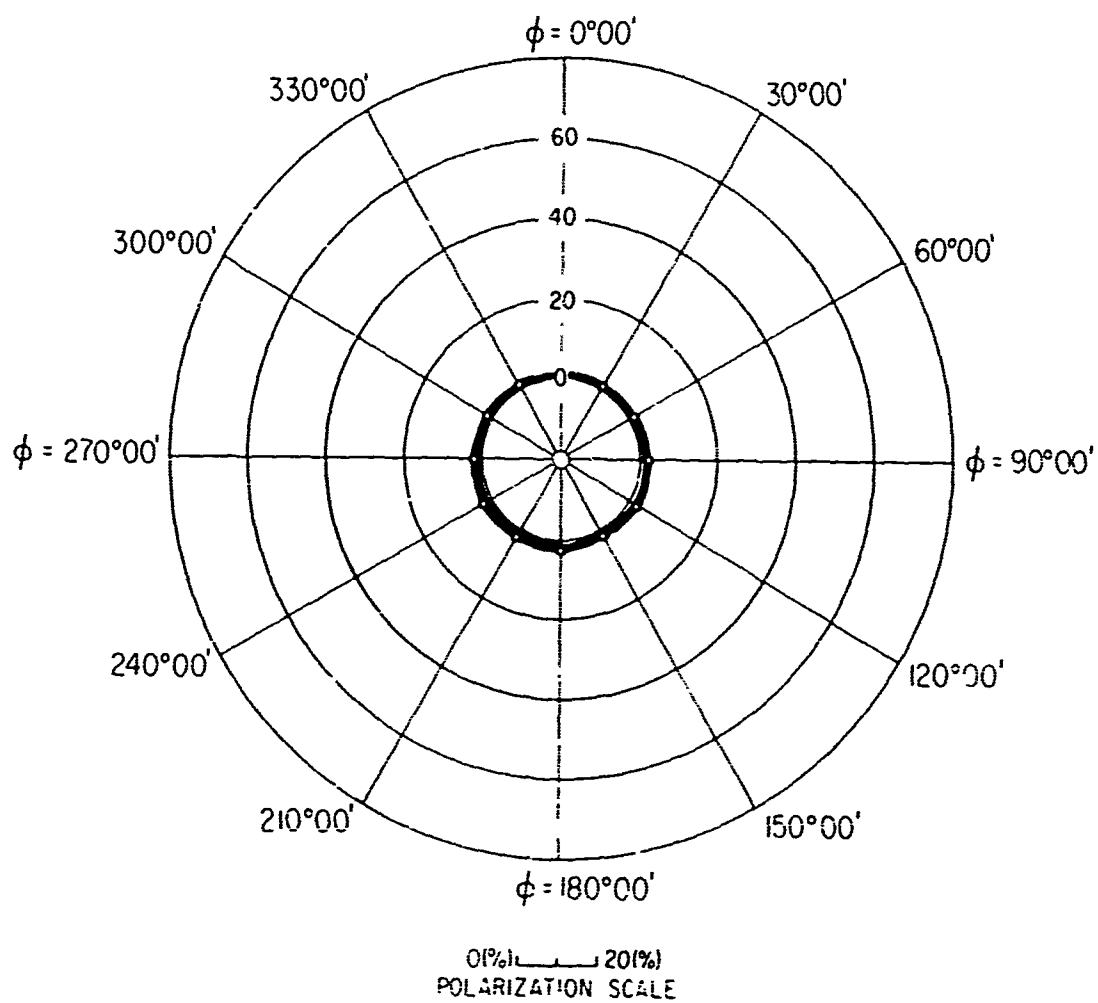


FIG 166 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT



SAMPLE WHITE SAND
 $\theta 10^\circ$

ILLUMINATION POLARIZED LIGHT \updownarrow
 $\theta_0 78^\circ 30'$

FIG 167 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 1.42 - 0.47 \cos \phi + 0.05 \cos 2\phi - 0.07 \cos 3\phi + 0.05 \cos 4\phi - 0.07 \cos 5\phi \\ + 0.15 \cos 6\phi - 0.14 \sin \phi - 0.23 \sin 2\phi - 0.05 \sin 3\phi + 0.00 \sin 4\phi + 0.04 \sin 5\phi$$

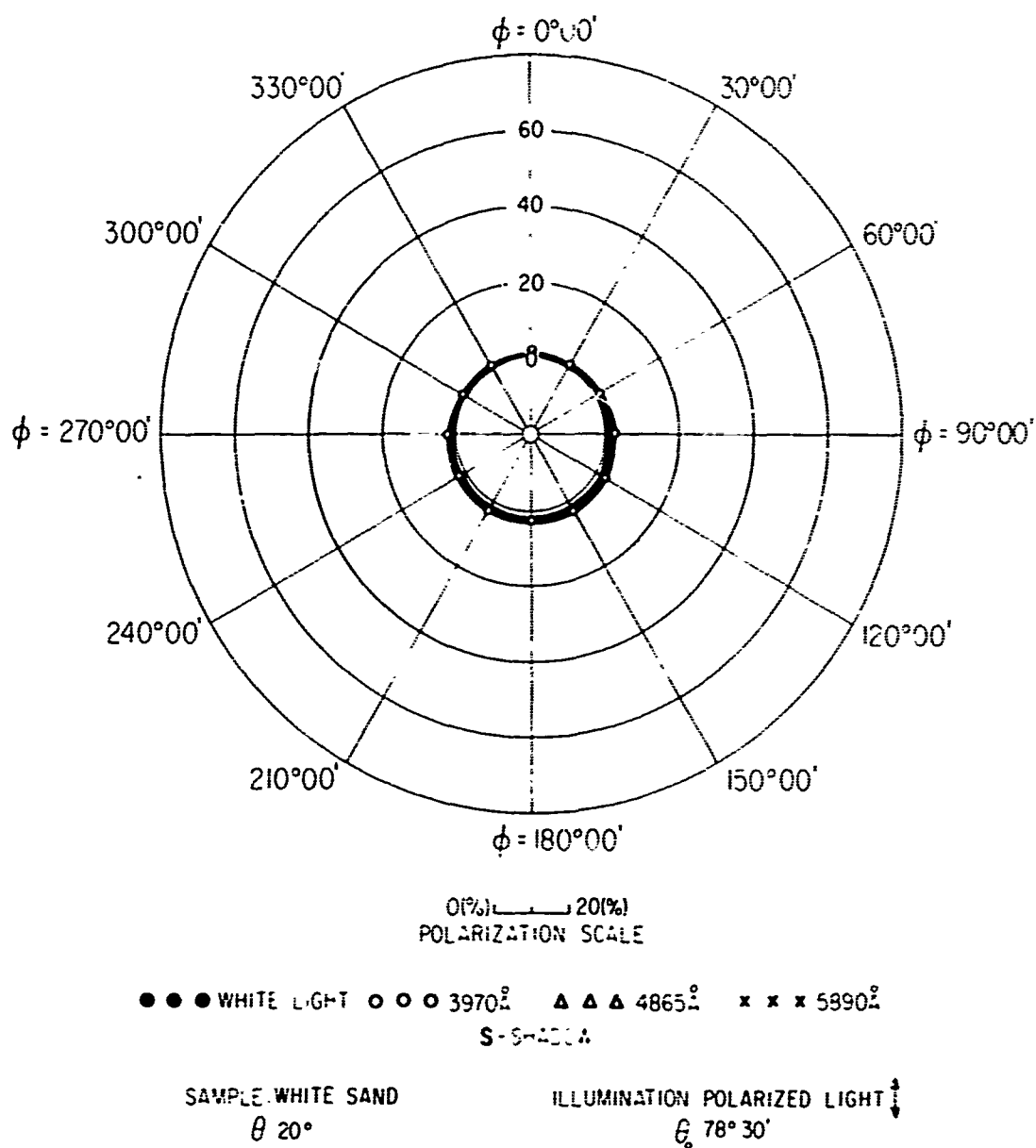


FIG.168 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 1.50 - 1.00 \cos \varphi - 0.02 \cos 2\varphi + 0.00 \cos 3\varphi - 0.01 \cos 4\varphi - 0.10 \cos 5\varphi \\
 & + 0.05 \cos 6\varphi + 0.19 \sin \varphi - 0.16 \sin 2\varphi - 0.22 \sin 3\varphi - 0.10 \sin 4\varphi - 0.10 \sin 5\varphi
 \end{aligned}$$

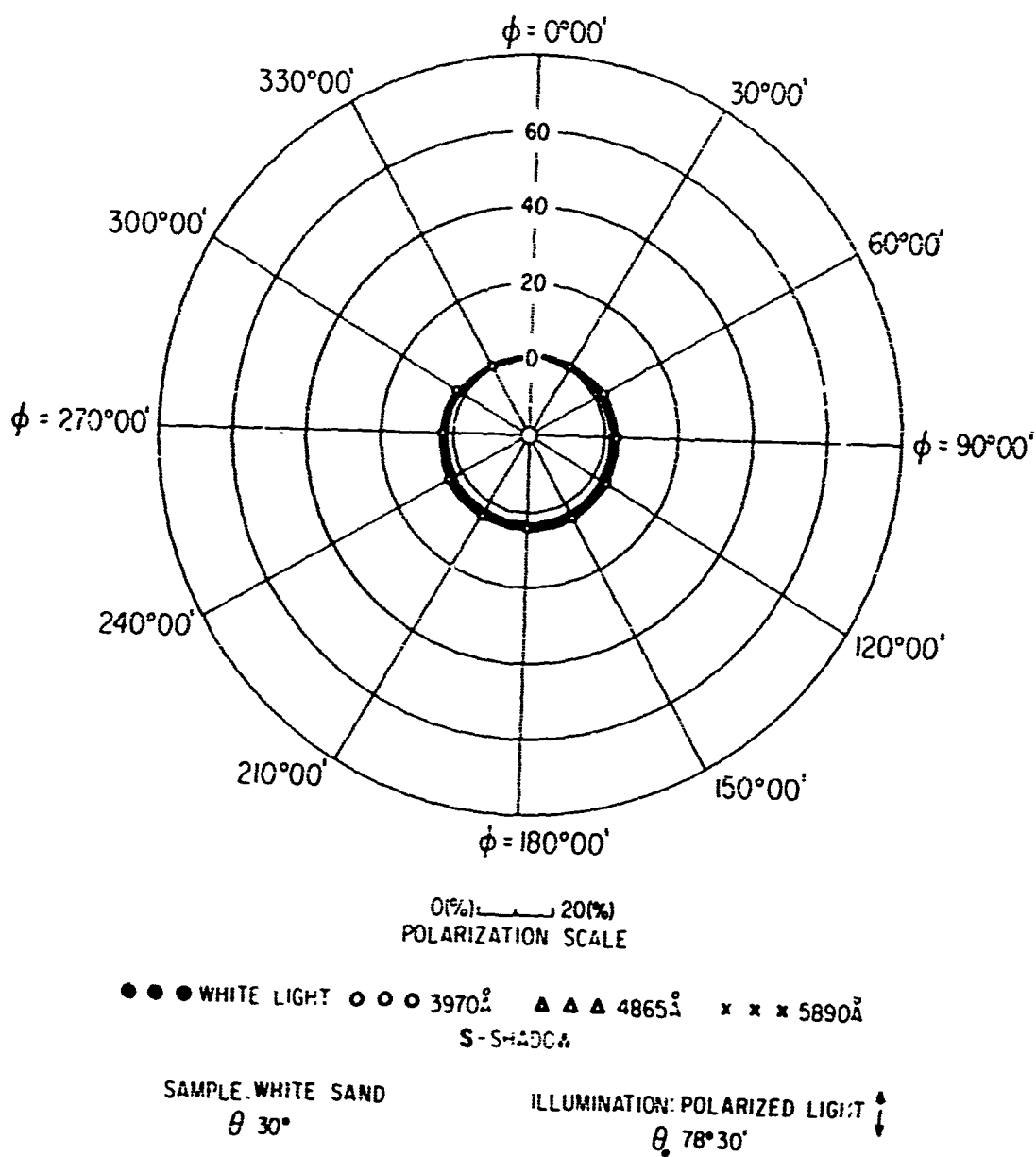


FIG 169 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 2.26 - 1.28 \cos \varphi - 0.39 \cos 2\varphi + 0.00 \cos 3\varphi + 0.32 \cos 4\varphi + 0.18 \cos 5\varphi \\ + 0.48 \cos 6\varphi + 0.04 \sin \varphi - 0.07 \sin 2\varphi + 0.08 \sin 3\varphi - 0.07 \sin 4\varphi + 0.04 \sin 5\varphi$$

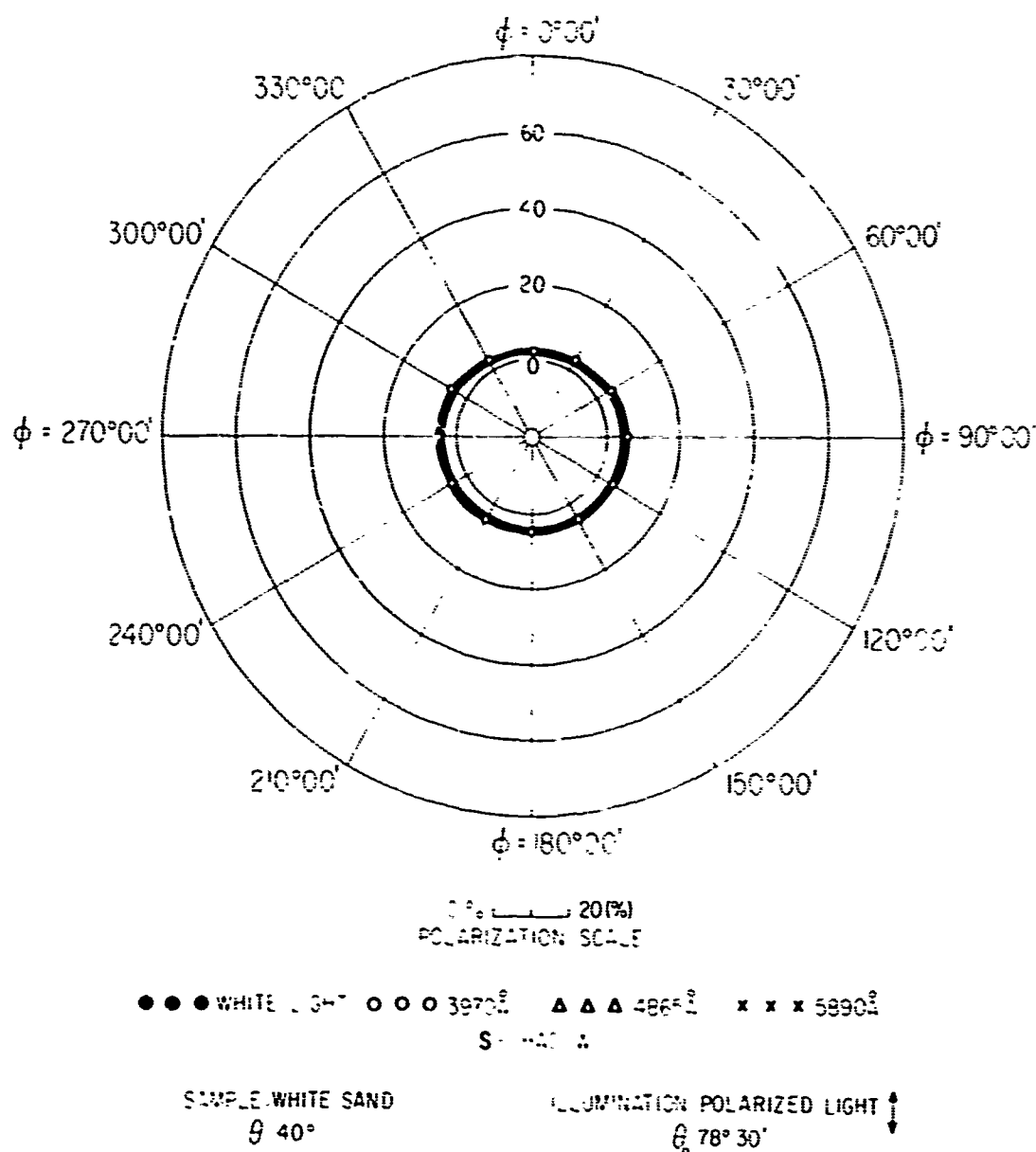


FIG 170 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 3.88 - 0.81 \cos \phi - 0.68 \cos 2\phi - 0.42 \cos 3\phi - 0.05 \cos 4\phi + 0.28 \cos 5\phi \\
 & + 0.22 \cos 6\phi + 0.00 \sin \phi + 0.00 \sin 2\phi + 0.00 \sin 3\phi + 0.00 \sin 4\phi + 0.00 \sin 5\phi
 \end{aligned}$$

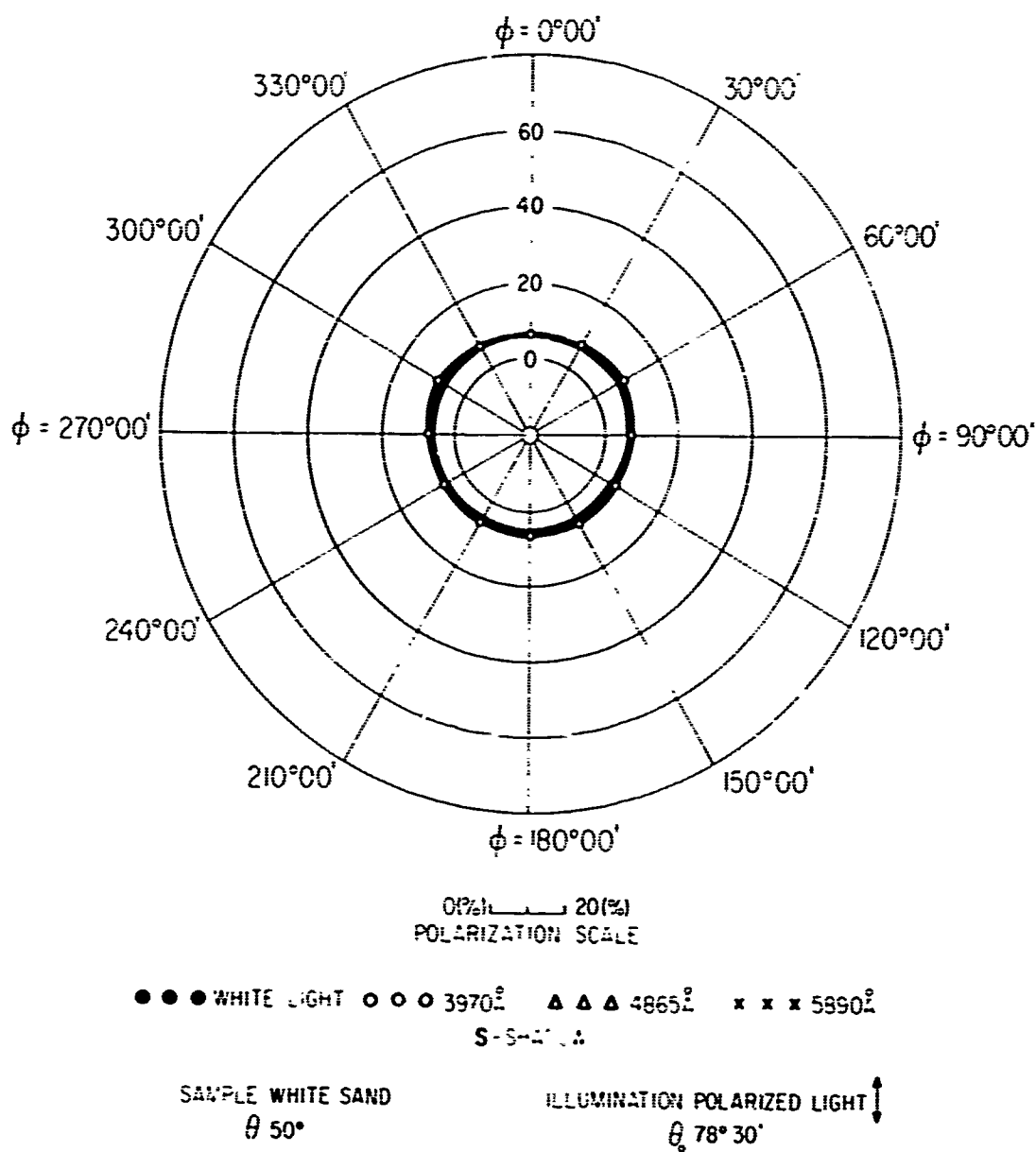


FIG. 171 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.32 + 0.95 \cos \varphi - 0.51 \cos 2\varphi - 0.65 \cos 3\varphi - 0.09 \cos 4\varphi + 0.05 \cos 5\varphi \\
 & + 0.27 \cos 6\varphi + 0.02 \sin \varphi + 0.04 \sin 2\varphi + 0.05 \sin 3\varphi + 0.04 \sin 4\varphi + 0.02 \sin 5\varphi
 \end{aligned}$$

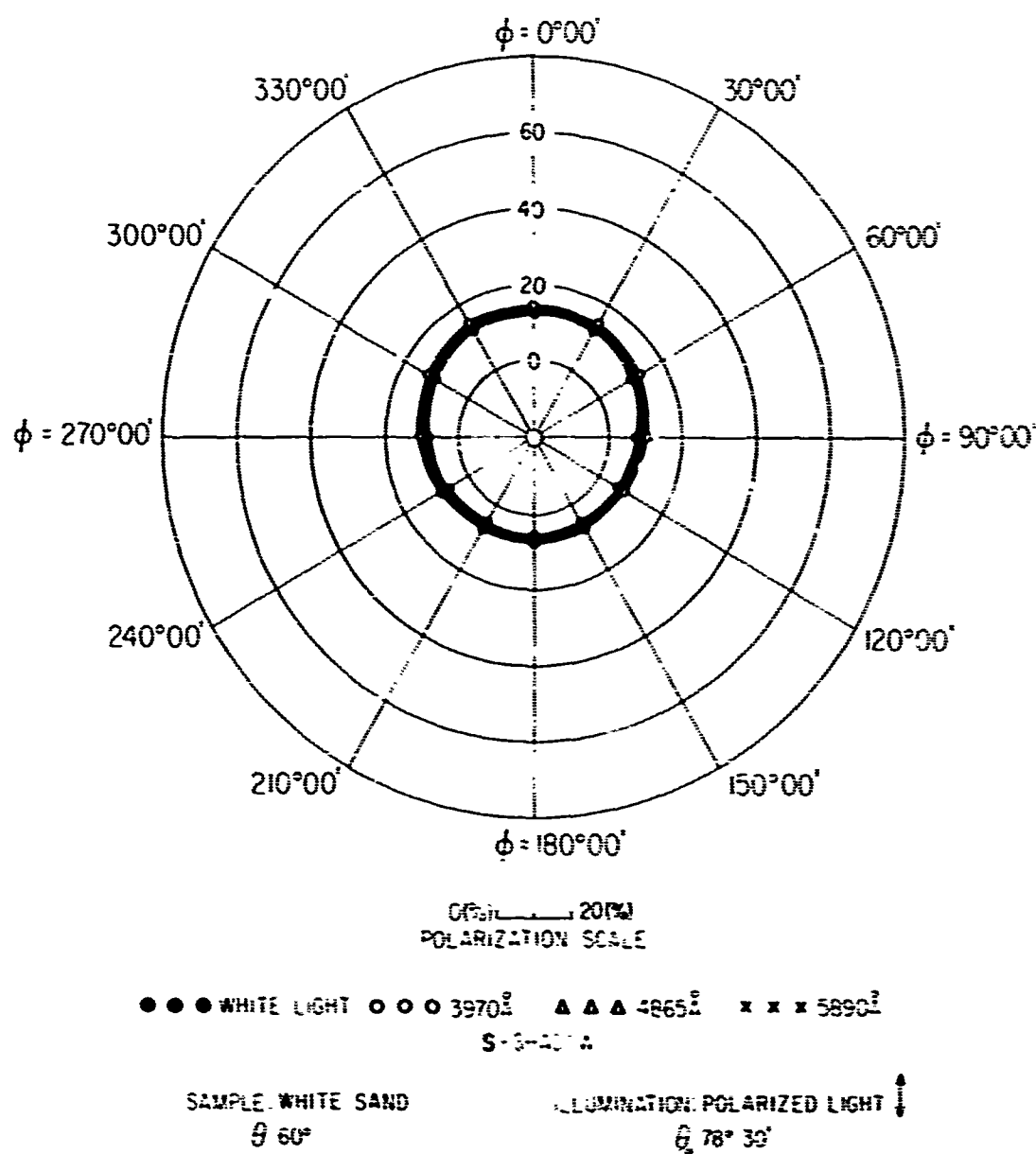


FIG 172 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 9.51 + 3.77 \cos \phi + 0.72 \cos 2\phi - 0.32 \cos 3\phi + 0.02 \cos 4\phi - 0.11 \cos 5\phi \\
 & + 0.02 \cos 6\phi + 0.00 \sin \phi + 0.00 \sin 2\phi + 0.00 \sin 3\phi + 0.00 \sin 4\phi + 0.00 \sin 5\phi
 \end{aligned}$$

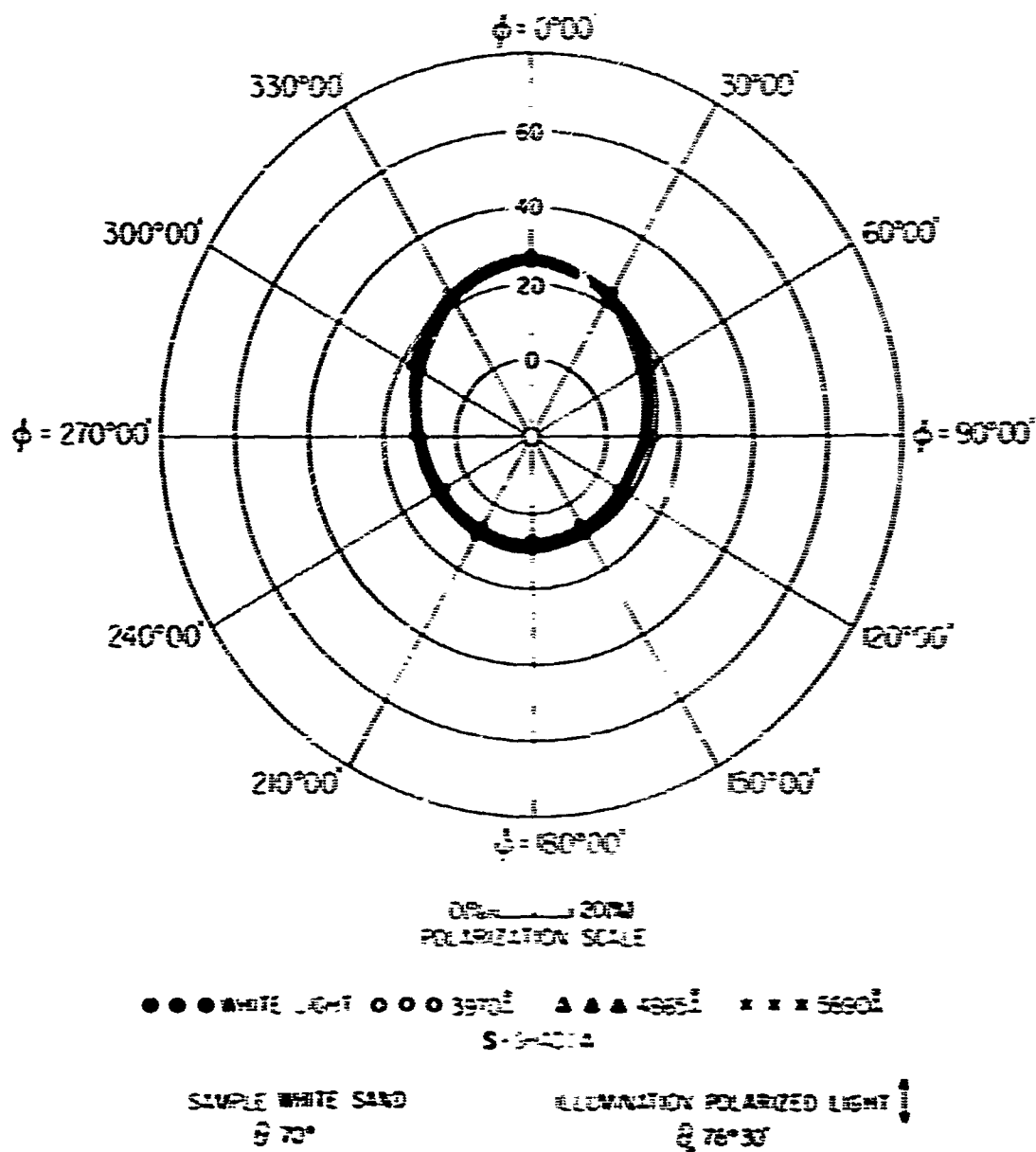


FIG. 173 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 13.43 + 8.57 \cos \phi + 3.82 \cos 2\phi + 0.67 \cos 3\phi + 0.72 \cos 4\phi - 0.03 \cos 5\phi \\
 & + 0.27 \cos 6\phi + 0.05 \sin \phi + 0.09 \sin 2\phi + 0.10 \sin 3\phi + 0.09 \sin 4\phi + 0.05 \sin 5\phi
 \end{aligned}$$

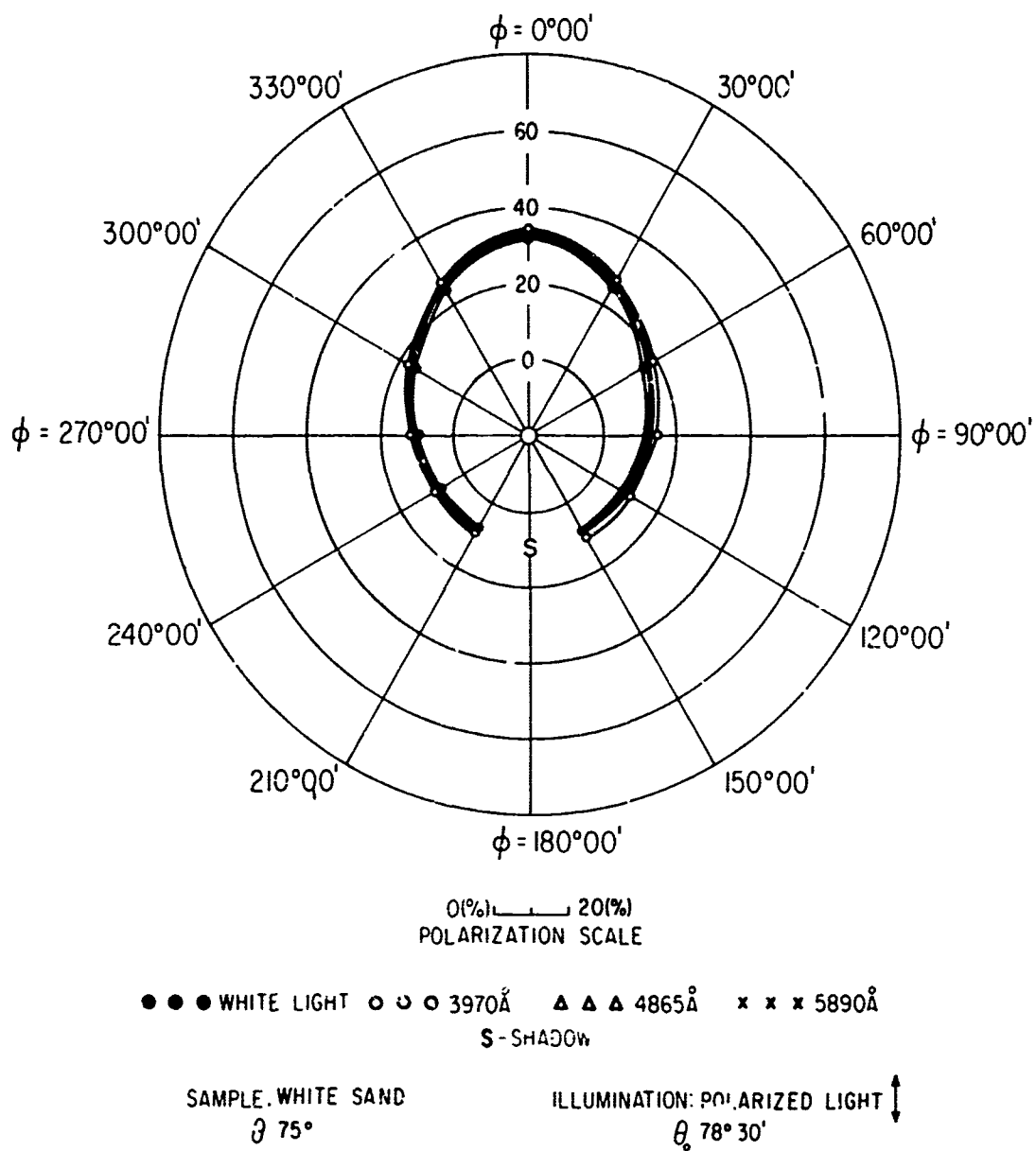
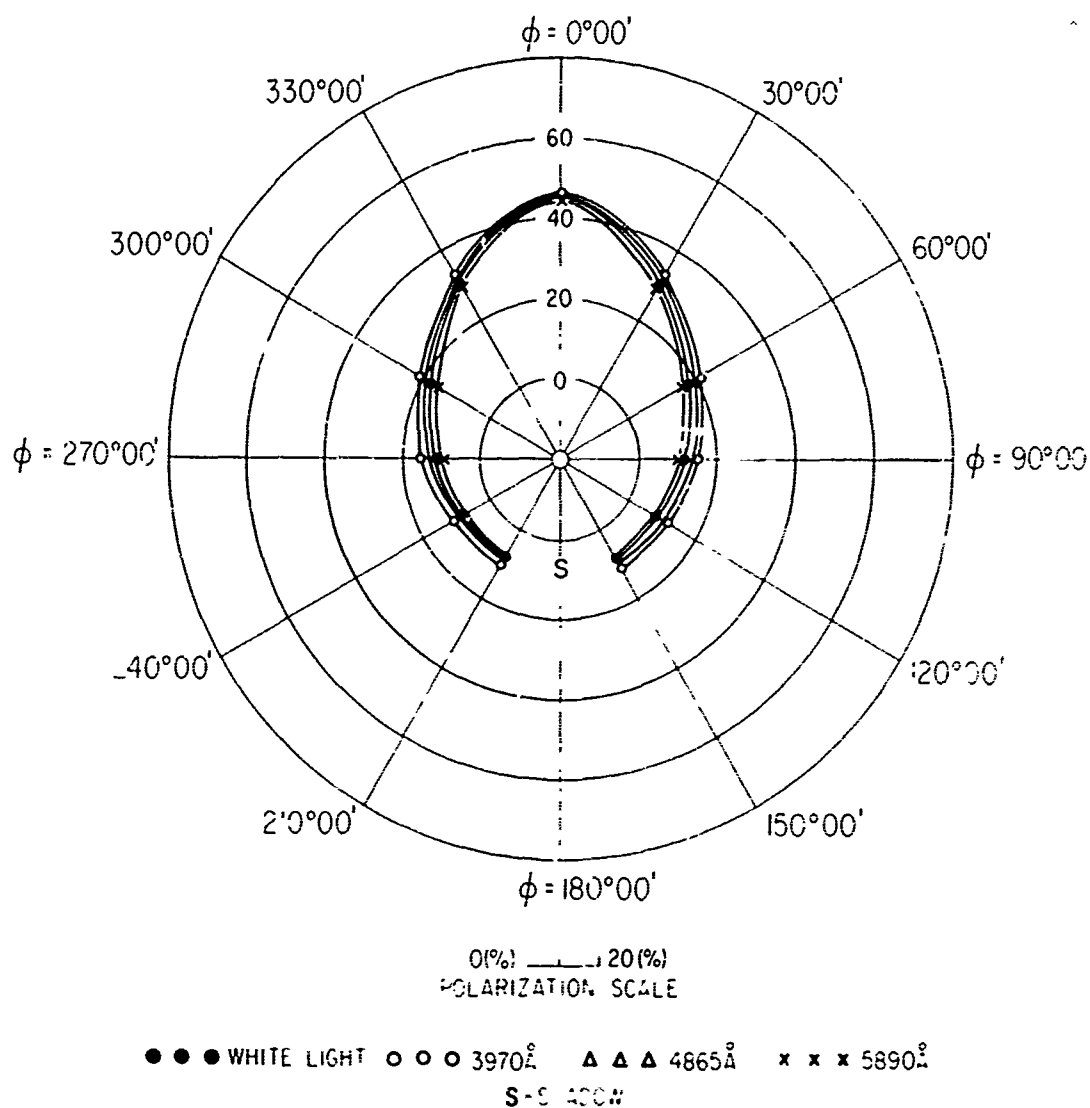


FIG 174 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P_{\phi} = 15.4 + 11.04 \cos \phi + 4.77 \cos 2\phi + 2.07 \cos 3\phi + 1.10 \cos 4\phi + 0.30 \cos 5\phi \\ + 0.27 \cos 6\phi + 0.13 \sin \phi - 0.06 \sin 2\phi + 0.27 \sin 3\phi - 0.06 \sin 4\phi + 0.13 \sin 5\phi$$



SAMPLE WHITE SAND
 $\theta 80^\circ$

ILLUMINATION POLARIZED LIGHT \updownarrow
 $\theta_i 78^\circ 30'$

FIG 175 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 16.91 + 14.40 \cos \phi + 7.53 \cos 2\phi + 2.98 \cos 3\phi + 1.92 \cos 4\phi + 1.52 \cos 5\phi \\
+ 1.28 \cos 6\phi + 0.04 \sin \phi + 0.06 \sin 2\phi - 0.03 \sin 3\phi - 0.03 \sin 4\phi + 0.07 \sin 5\phi$$

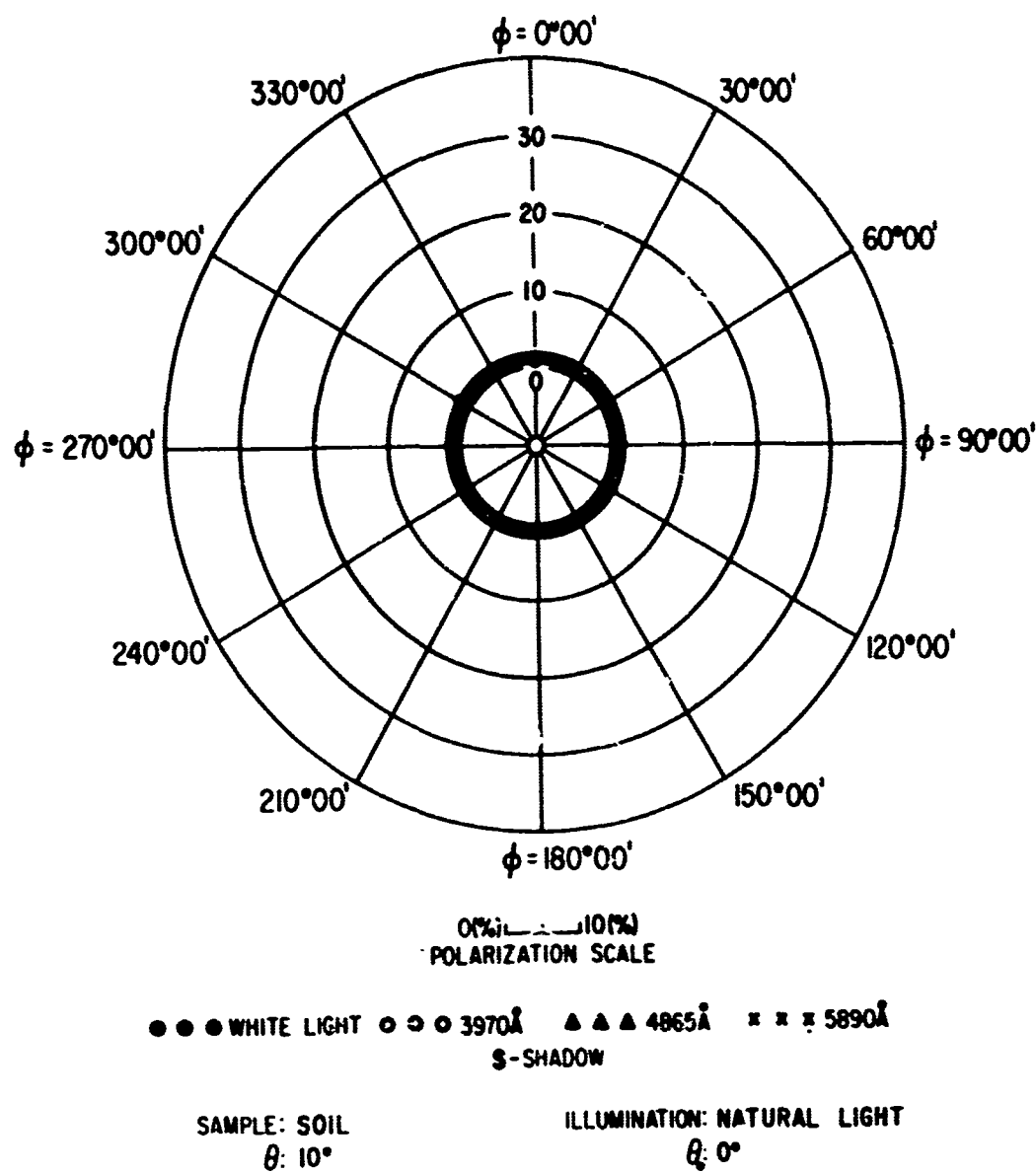
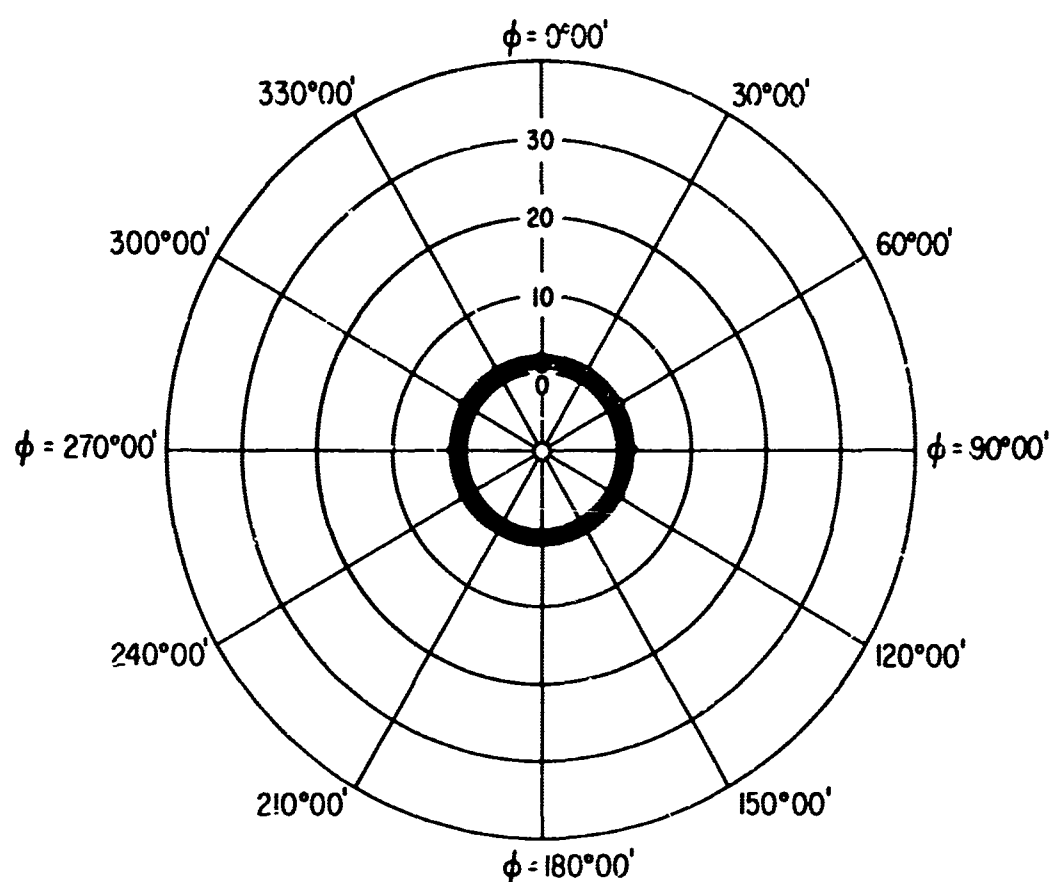


FIG. 176. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT



0(%) ——— 10(%)
POLARIZATION SCALE

● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
S-SHADOW

SAMPLE. SOIL
 θ 20°

ILLUMINATION: NATURAL LIGHT
 ϕ 0°

FIG. 177. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

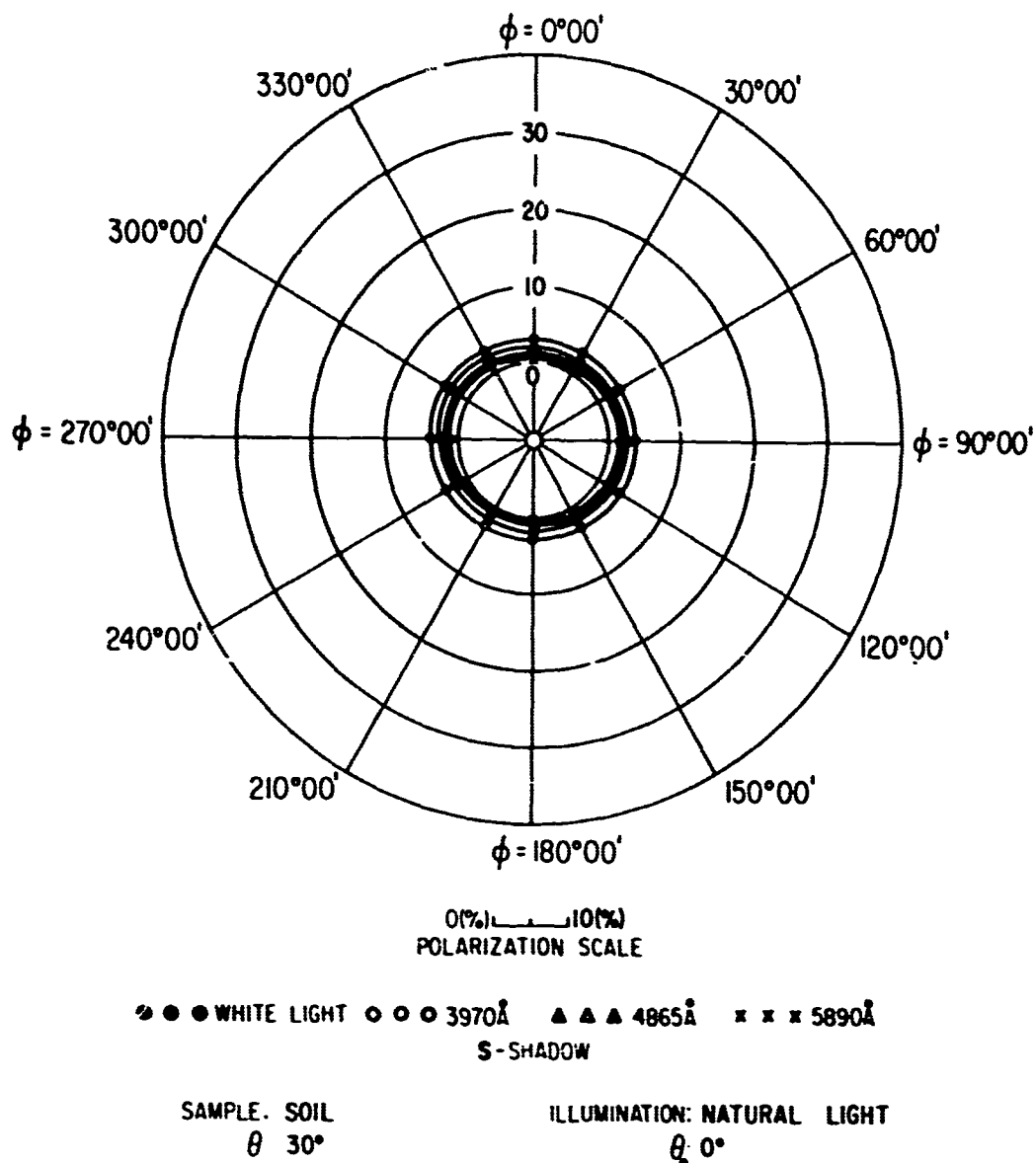


FIG. 178. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

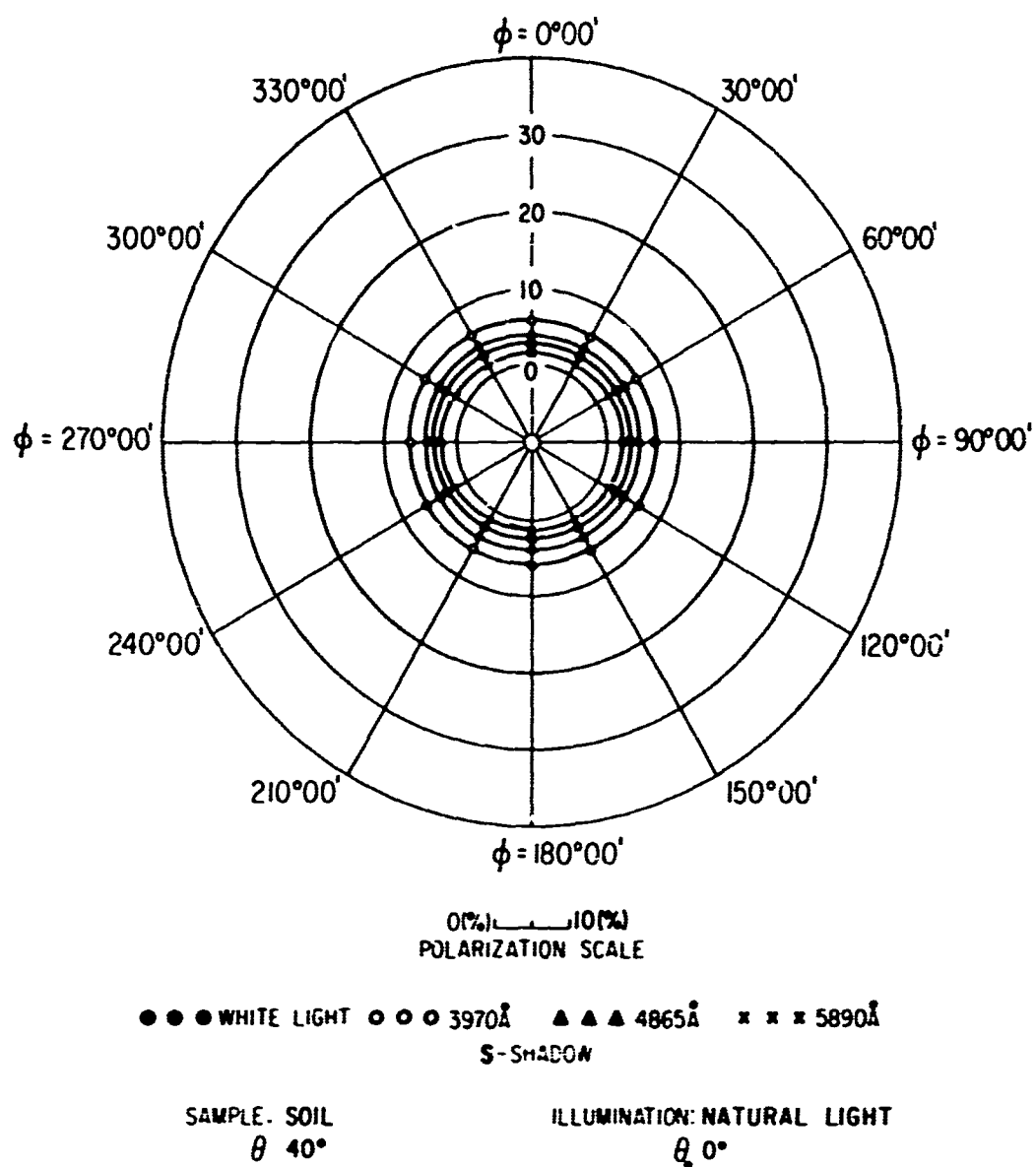


FIG.179. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

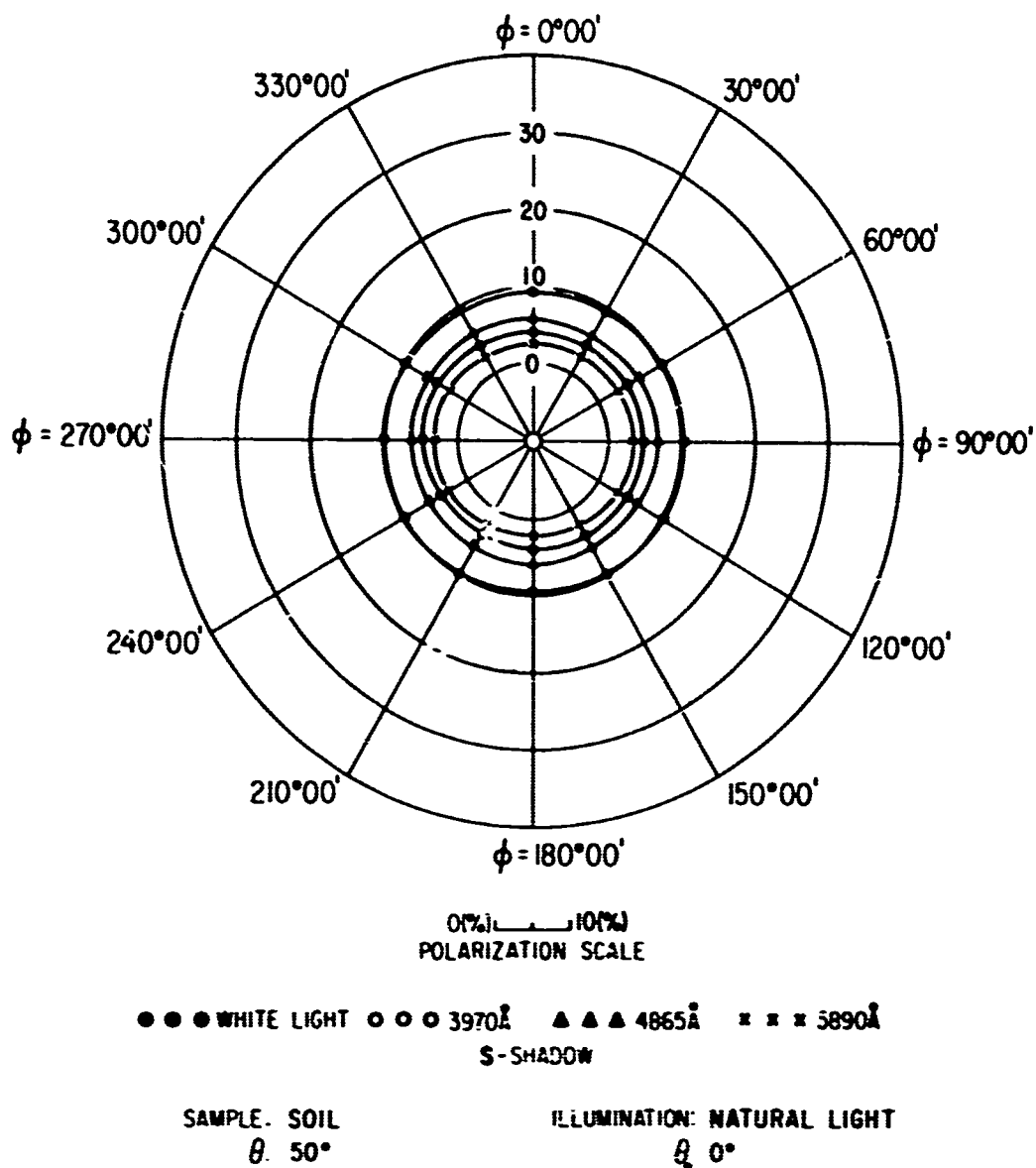


FIG. 180. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

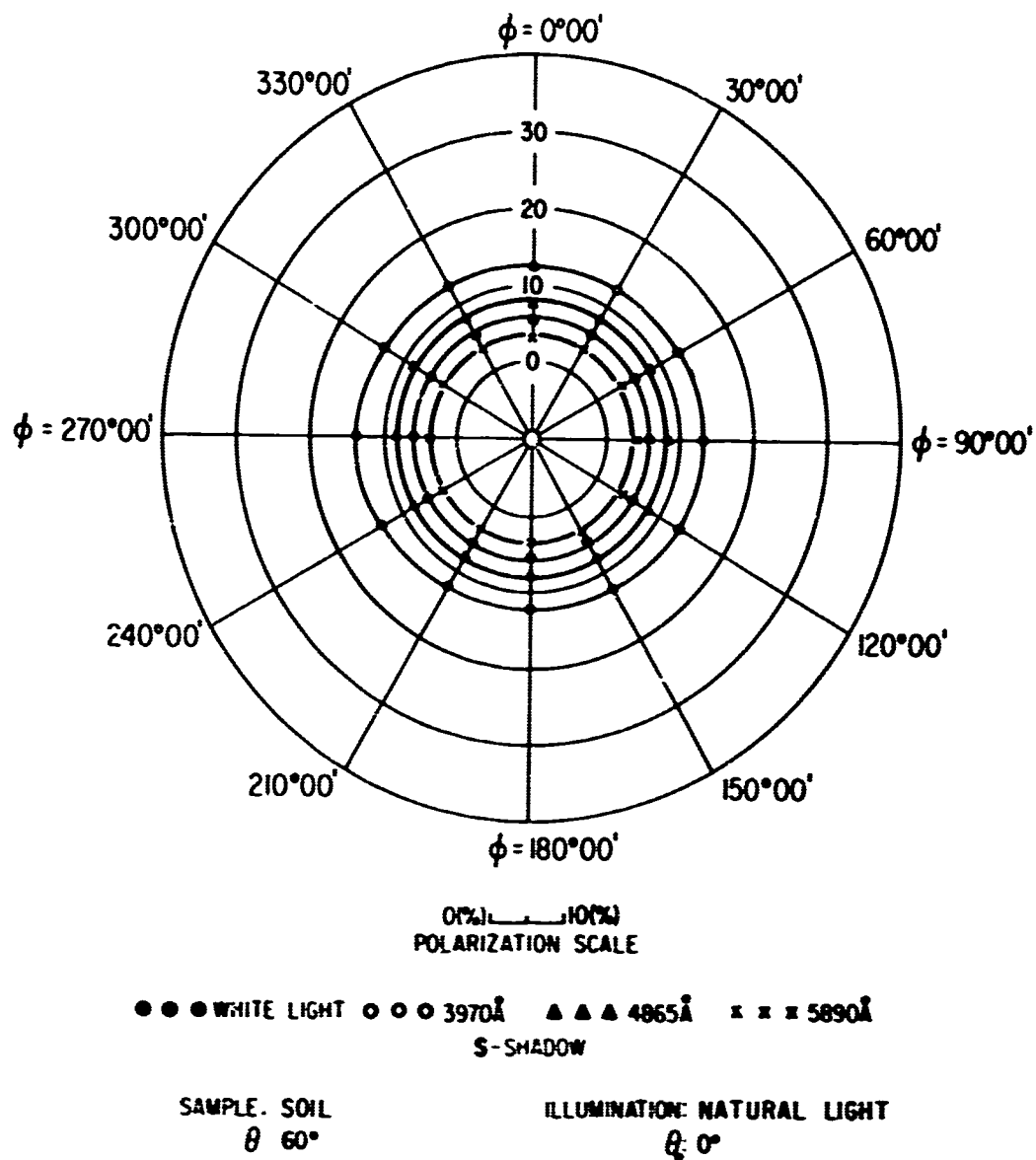


FIG.181. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

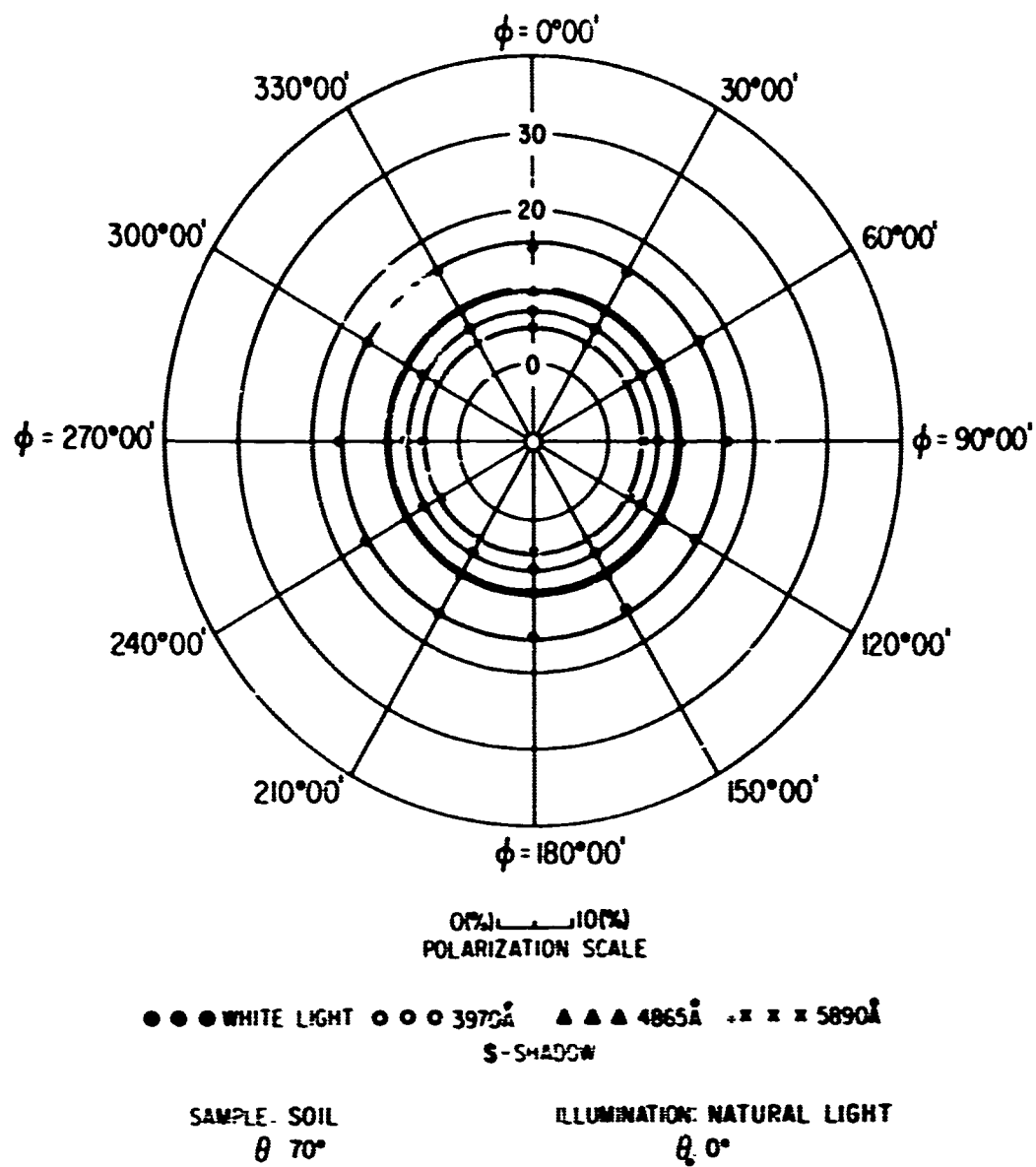


FIG. 182. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

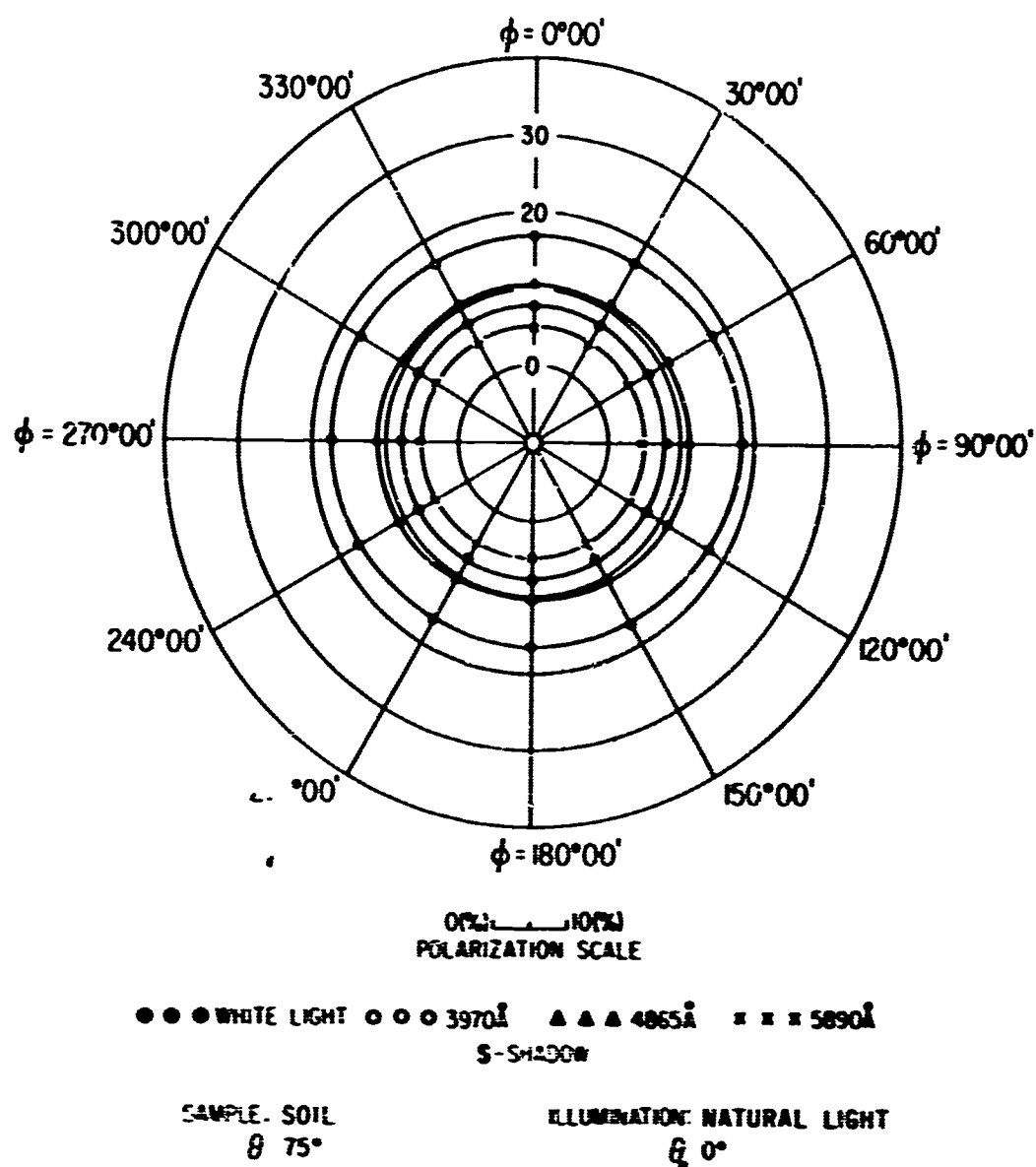


FIG. 183. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

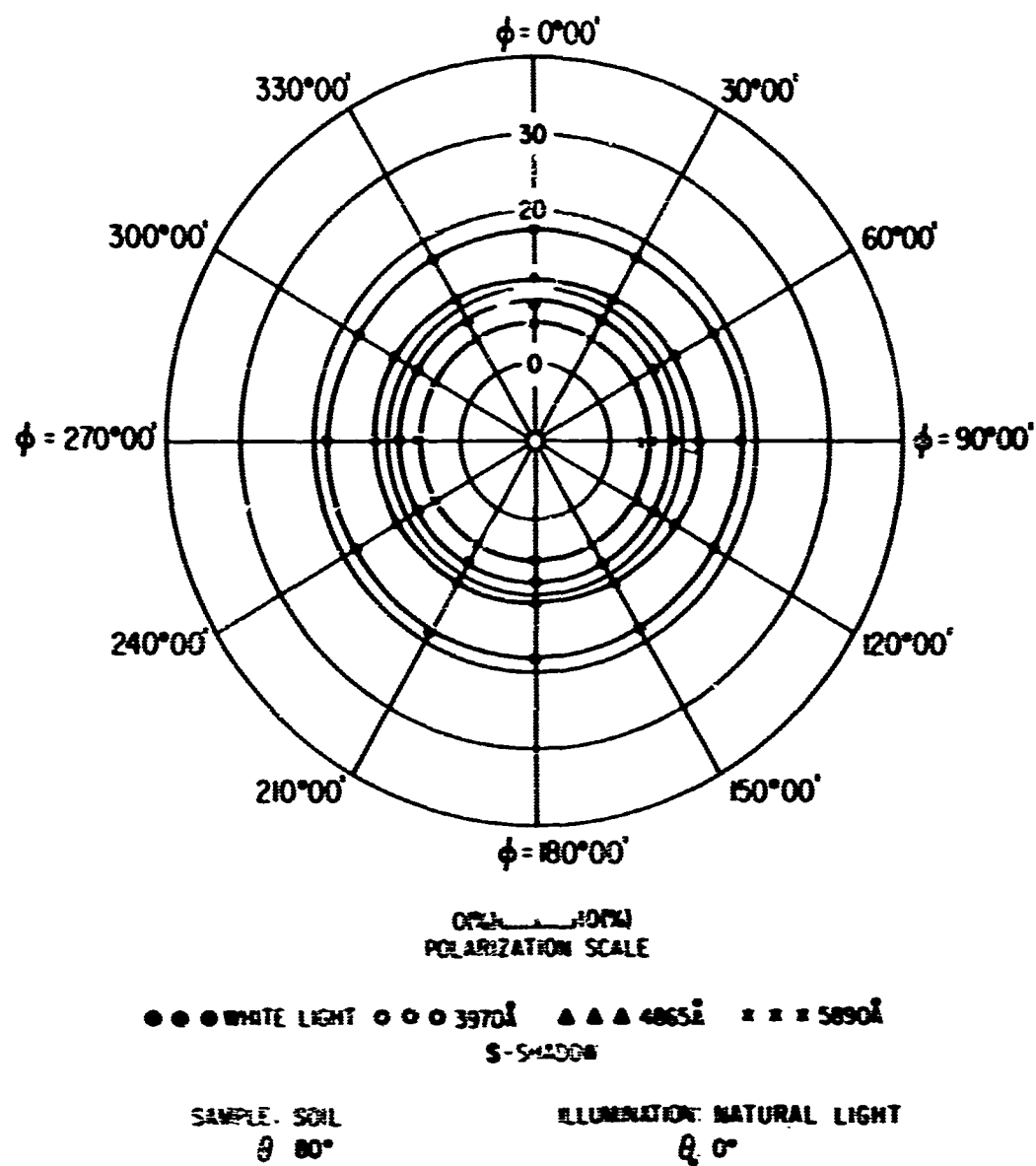


FIG. 184. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

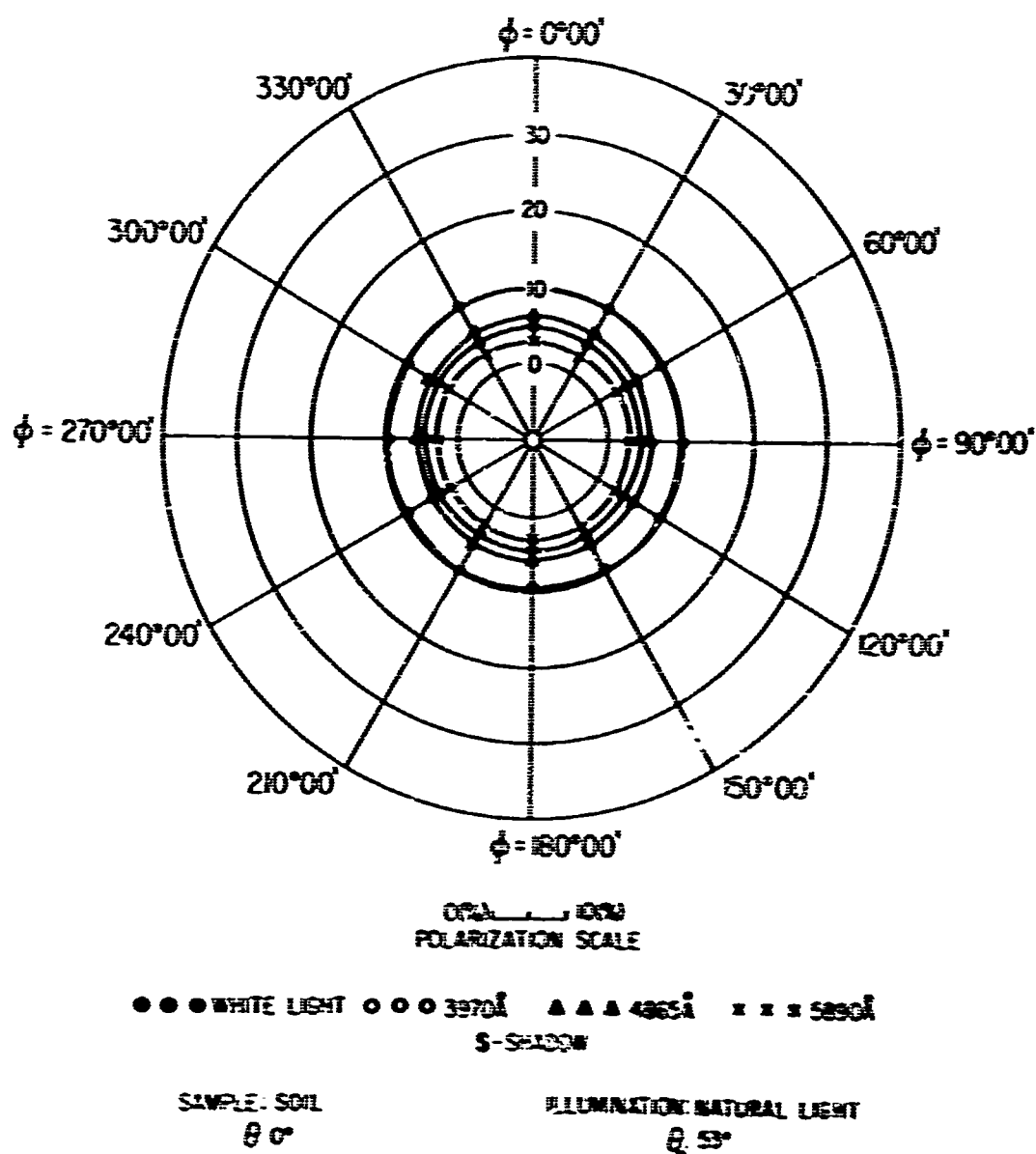


FIG 185 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

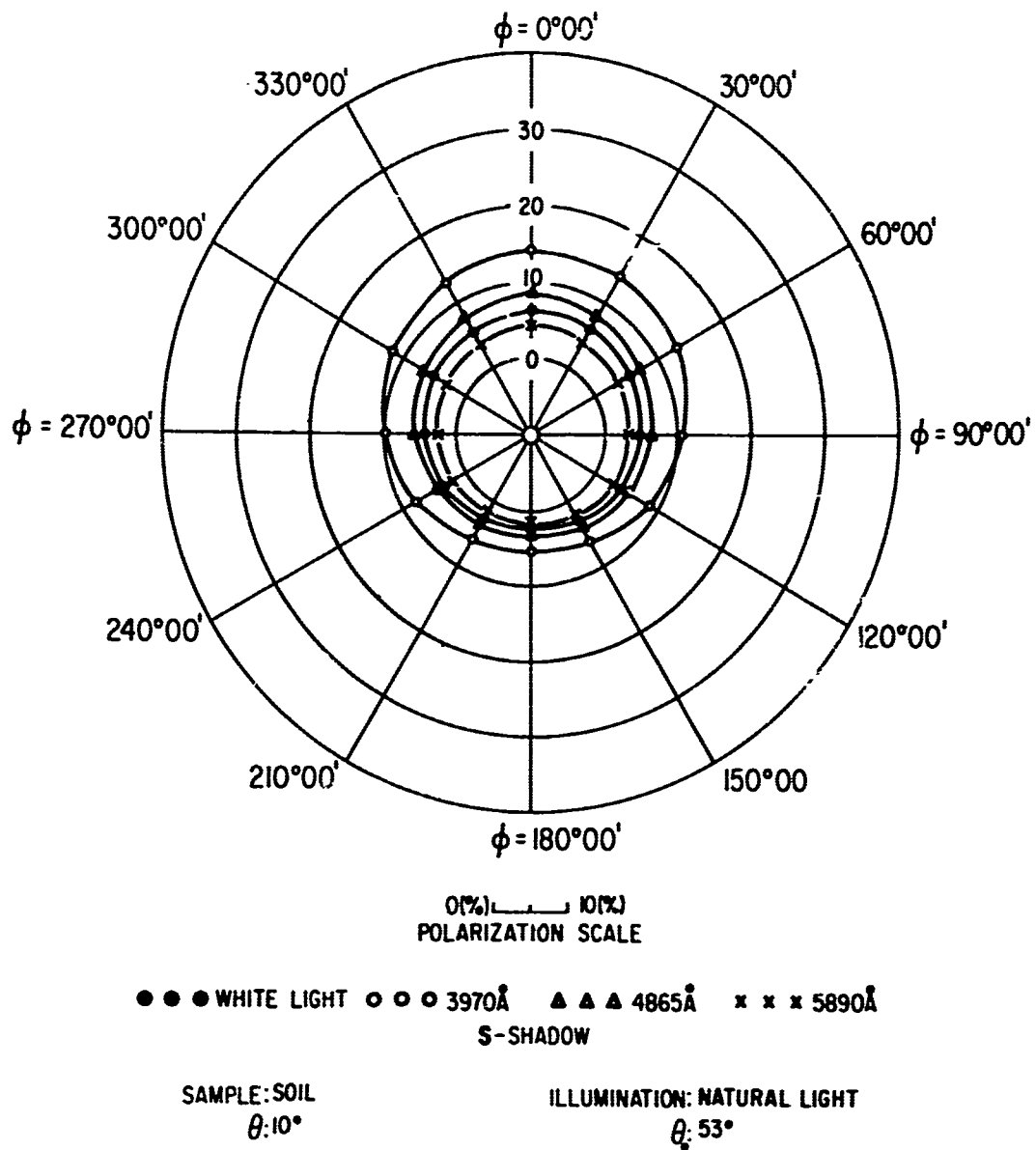


FIG. 186 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 4.62 + 1.32 \cos \varphi + 0.56 \cos 2\varphi - 0.45 \cos 3\varphi + 0.52 \cos 4\varphi - 0.47 \cos 5\varphi \\
 & + 0.58 \cos 6\varphi + 0.16 \sin \varphi - 0.01 \sin 2\varphi + 0.07 \sin 3\varphi - 0.04 \sin 4\varphi + 0.01 \sin 5\varphi
 \end{aligned}$$

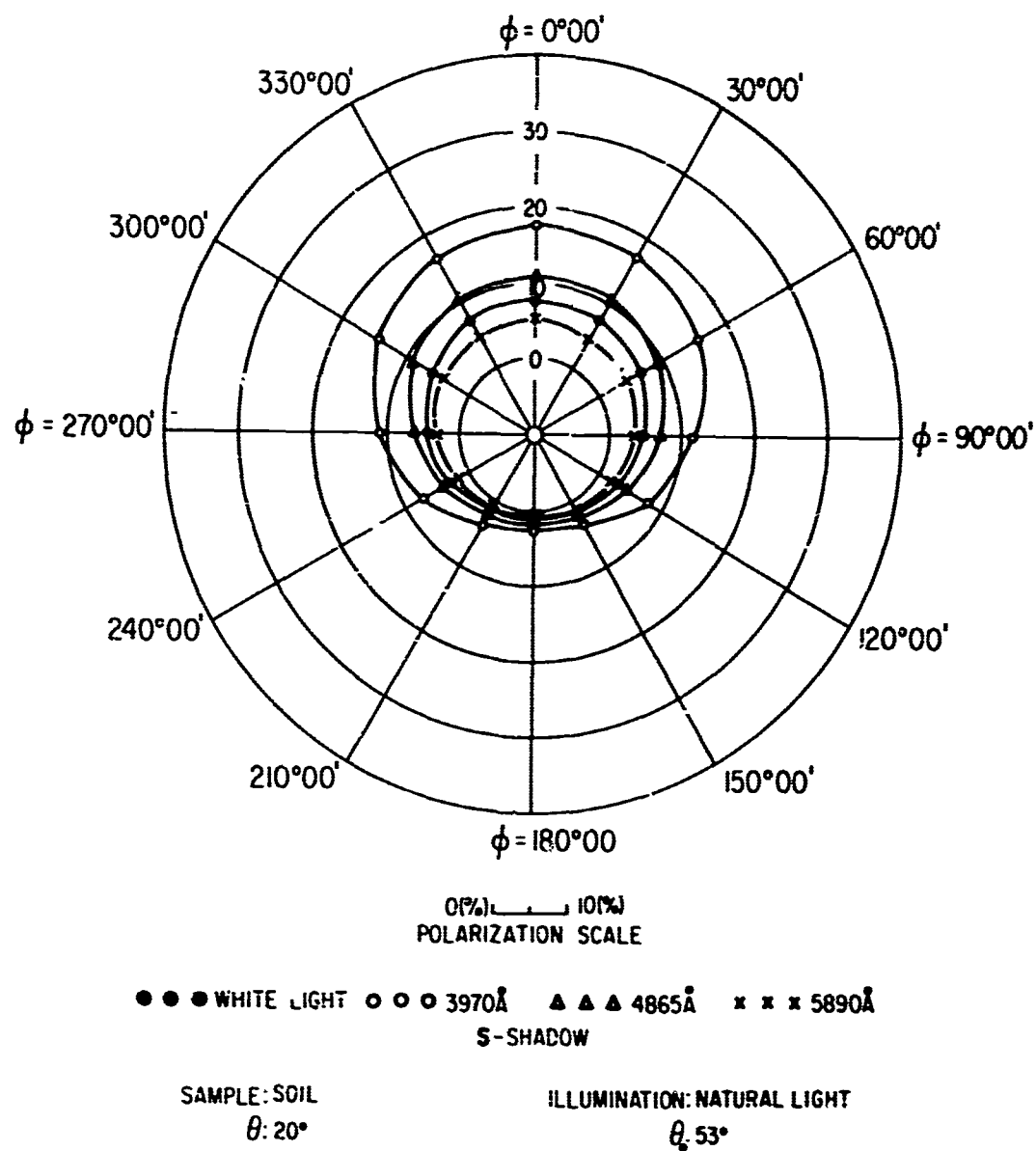


FIG.187 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 4.69 + 3.32 \cos \varphi - 0.19 \cos 2\varphi + 0.02 \cos 3\varphi - 0.09 \cos 4\varphi - 0.03 \cos 5\varphi \\
 & - 0.02 \cos 6\varphi + 0.05 \sin \varphi - 0.01 \sin 2\varphi - 0.03 \sin 3\varphi - 0.04 \sin 4\varphi + 0.02 \sin 5\varphi
 \end{aligned}$$

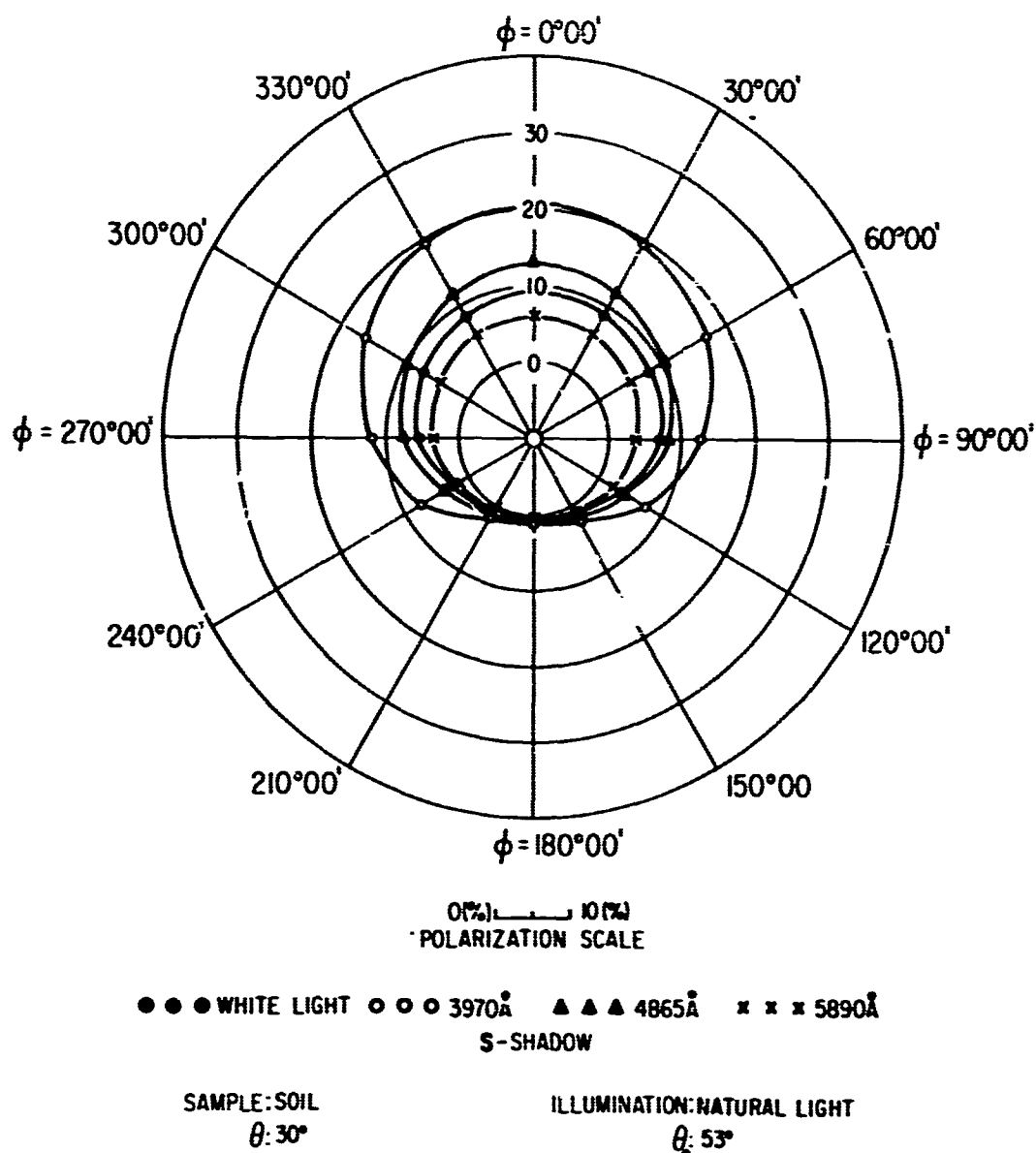


FIG. 188 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 5.04 + 4.65 \cos \varphi - 0.44 \cos 2\varphi + 0.28 \cos 3\varphi + 0.01 \cos 4\varphi - 0.02 \cos 5\varphi \\
 & + 0.08 \cos 6\varphi + 0.17 \sin \varphi + 0.10 \sin 2\varphi + 0.07 \sin 3\varphi + 0.04 \sin 4\varphi + 0.08 \sin 5\varphi
 \end{aligned}$$

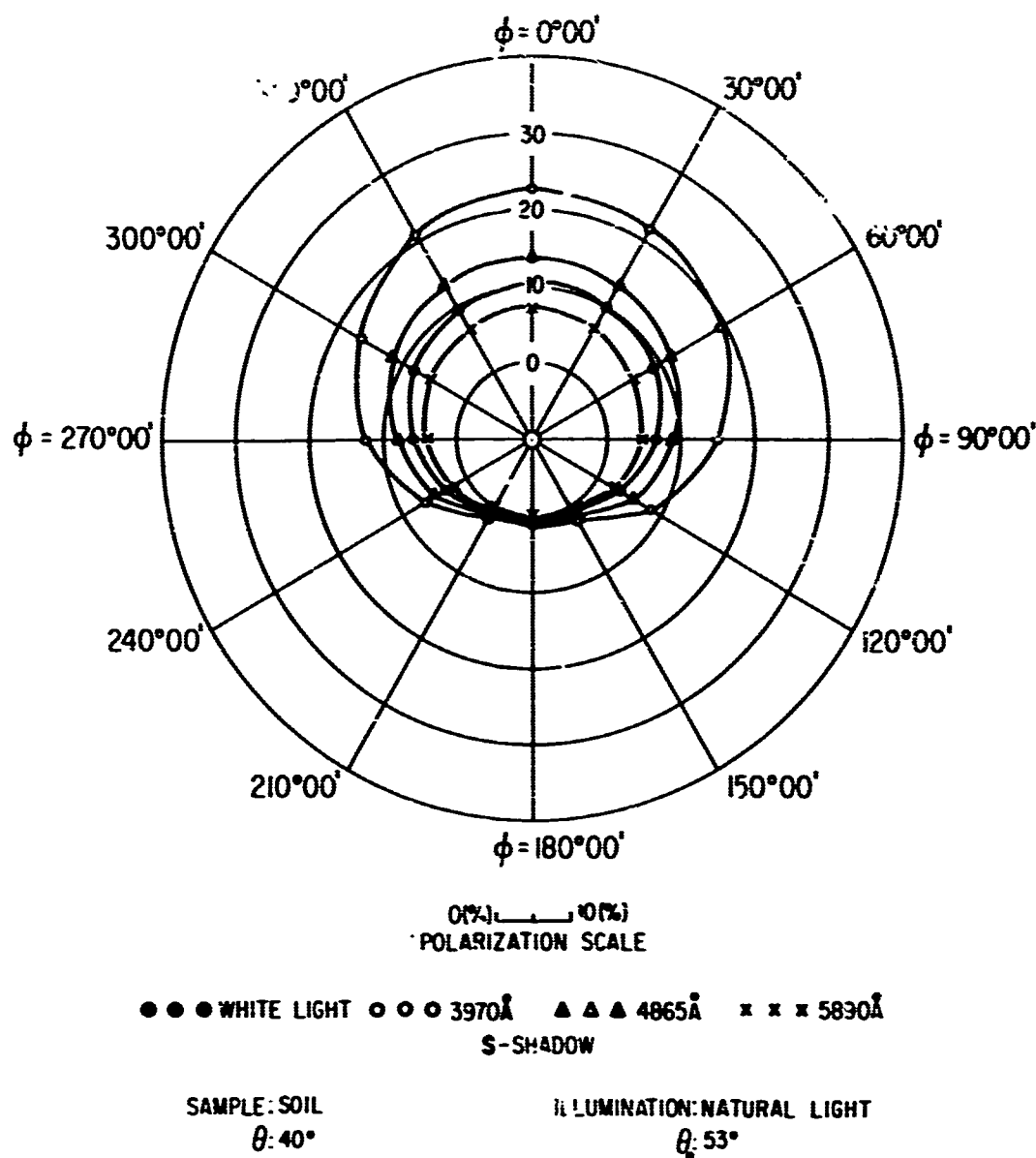


FIG.189 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 5.58 + 5.04 \cos \varphi - 0.33 \cos 2\varphi + 0.07 \cos 3\varphi + 0.25 \cos 4\varphi - 0.06 \cos 5\varphi \\
 & + 0.12 \cos 6\varphi + 0.21 \sin \varphi - 0.06 \sin 2\varphi - 0.43 \sin 3\varphi - 0.03 \sin 4\varphi + 0.01 \sin 5\varphi
 \end{aligned}$$

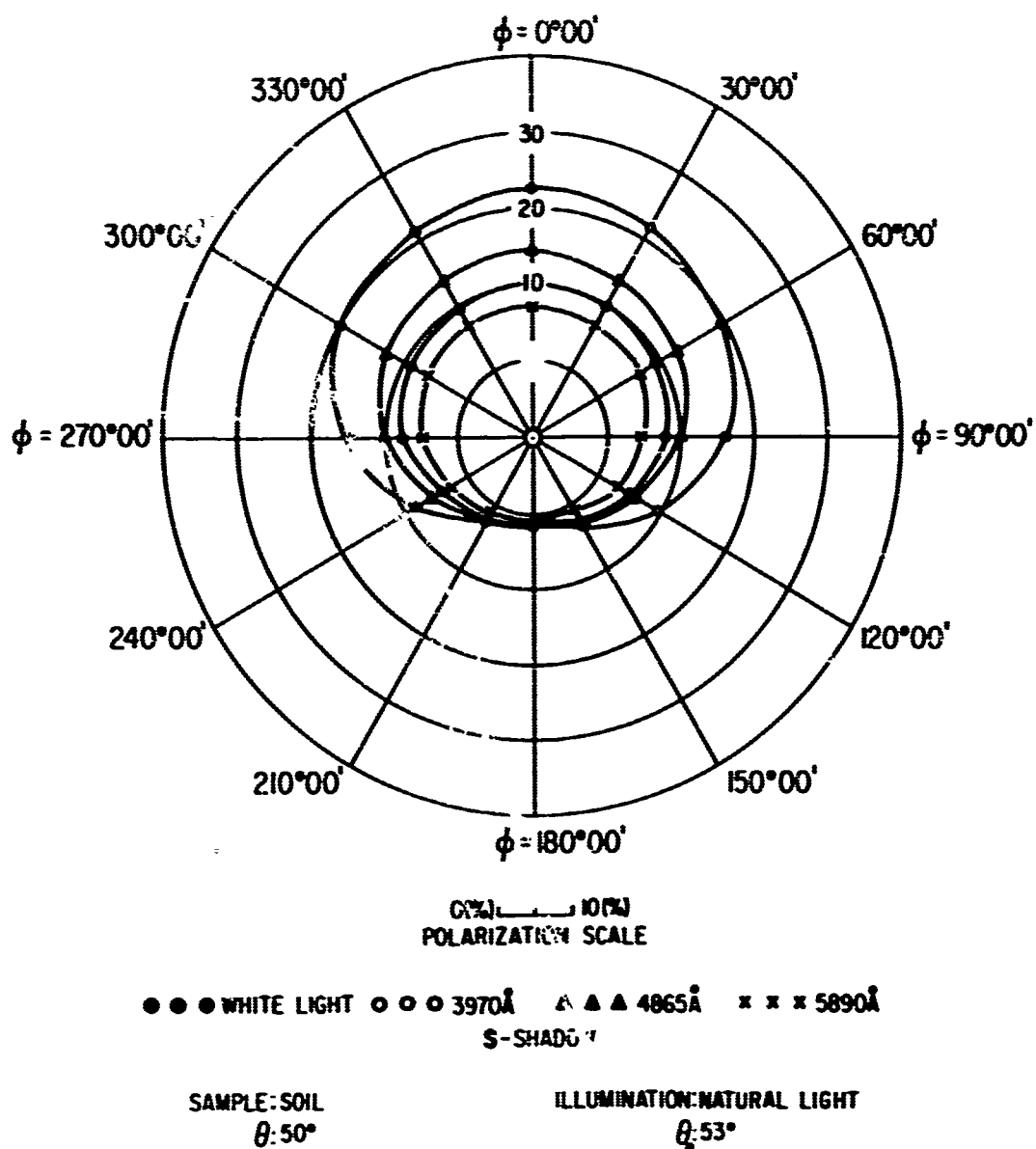


FIG. 190 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.23 + 4.99 \cos \varphi - 0.76 \cos 2\varphi - 0.04 \cos 3\varphi + 0.14 \cos 4\varphi - 0.15 \cos 5\varphi \\
 & + 0.17 \cos 6\varphi + 0.06 \sin \varphi + 1.04 \sin 2\varphi - 0.02 \sin 3\varphi - 0.04 \sin 4\varphi - 0.03 \sin 5\varphi
 \end{aligned}$$

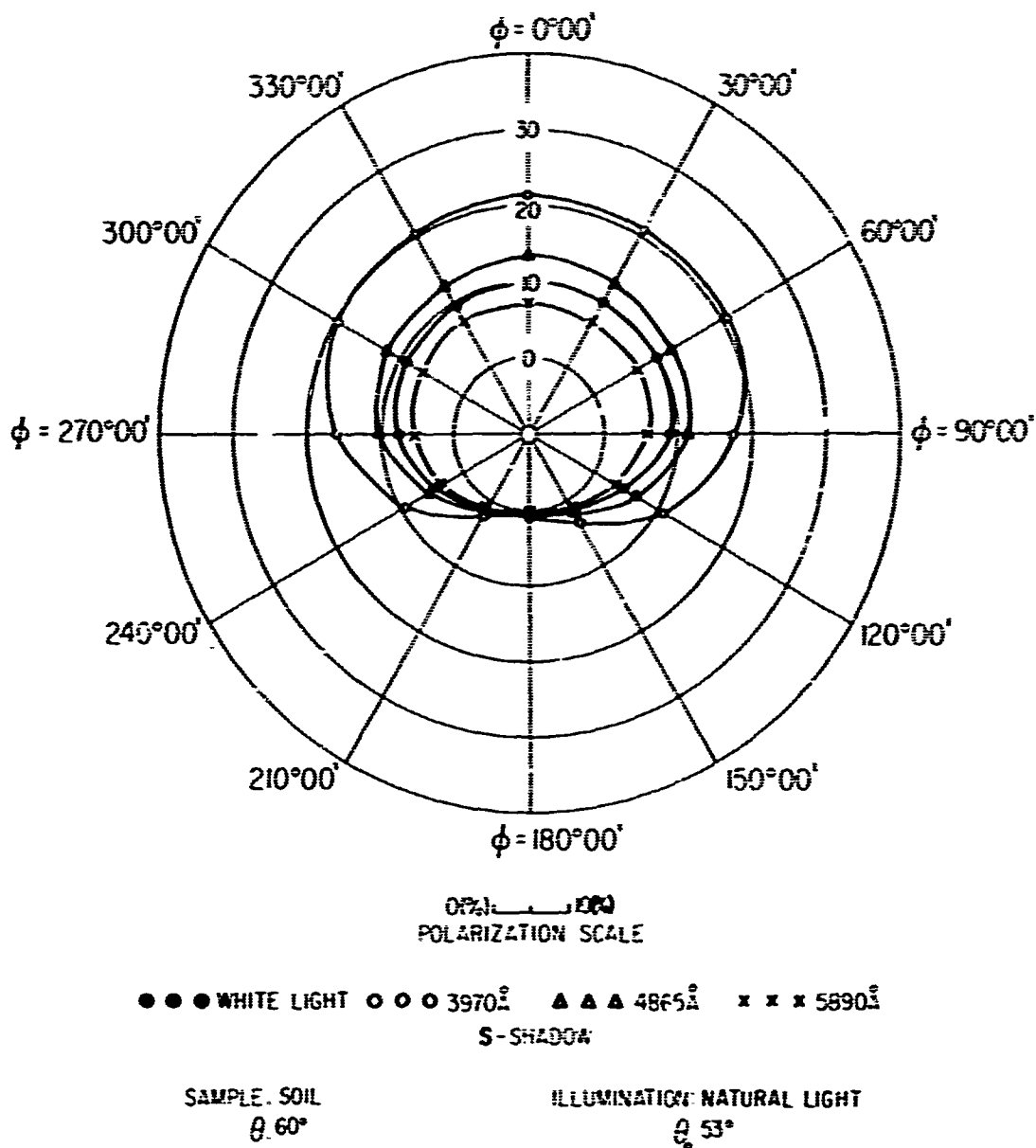


FIG. 191 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 6.35 + 4.80 \cos \varphi - 1.07 \cos 2\varphi - 0.23 \cos 3\varphi + 0.30 \cos 4\varphi + 0.02 \cos 5\varphi \\ + 0.03 \cos 6\varphi + 0.03 \sin \varphi + 0.14 \sin 2\varphi + 0.07 \sin 3\varphi - 0.20 \sin 4\varphi + 0.20 \sin 5\varphi$$

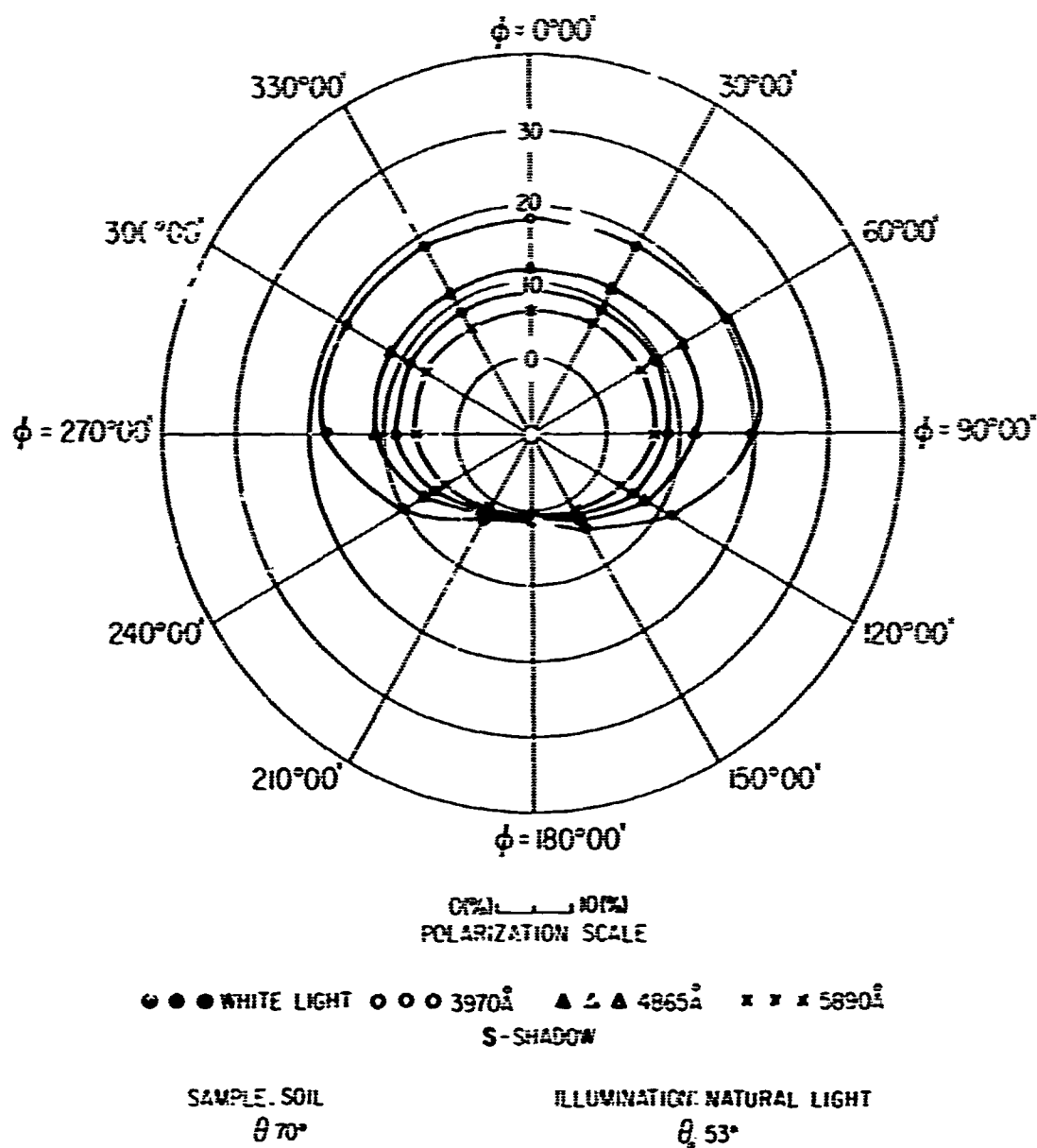
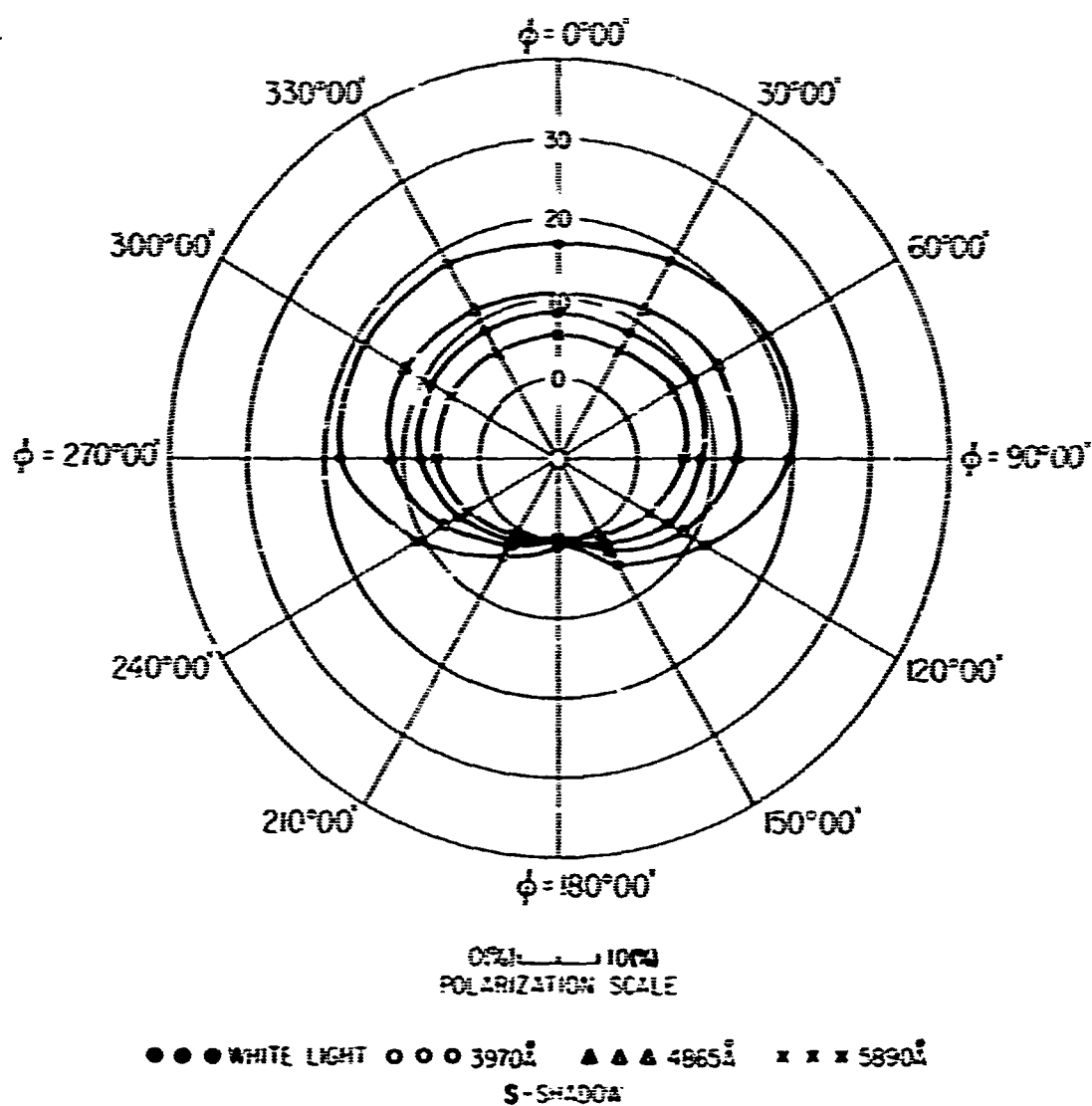


FIG. 192 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 6.38 + 3.85 \cos \phi - 1.76 \cos 2\phi + 0.10 \cos 3\phi + 0.09 \cos 4\phi - 0.05 \cos 5\phi \\
 & + 0.37 \cos 6\phi + 0.12 \sin \phi + 0.16 \sin 2\phi + 0.17 \sin 3\phi - 0.07 \sin 4\phi - 0.11 \sin 5\phi
 \end{aligned}$$



SAMPLE SOIL
 θ 75°

ILLUMINATION: NATURAL LIGHT
 θ 53°

FIG 193 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 6.33 + 3.71 \cos \varphi - 2.09 \cos 2\varphi - 0.02 \cos 3\varphi - 0.22 \cos 4\varphi + 0.07 \cos 5\varphi \\ + 0.50 \cos 6\varphi + 0.36 \sin \varphi + 0.10 \sin 2\varphi + 0.10 \sin 3\varphi - 0.08 \sin 4\varphi - 0.10 \sin 5\varphi$$

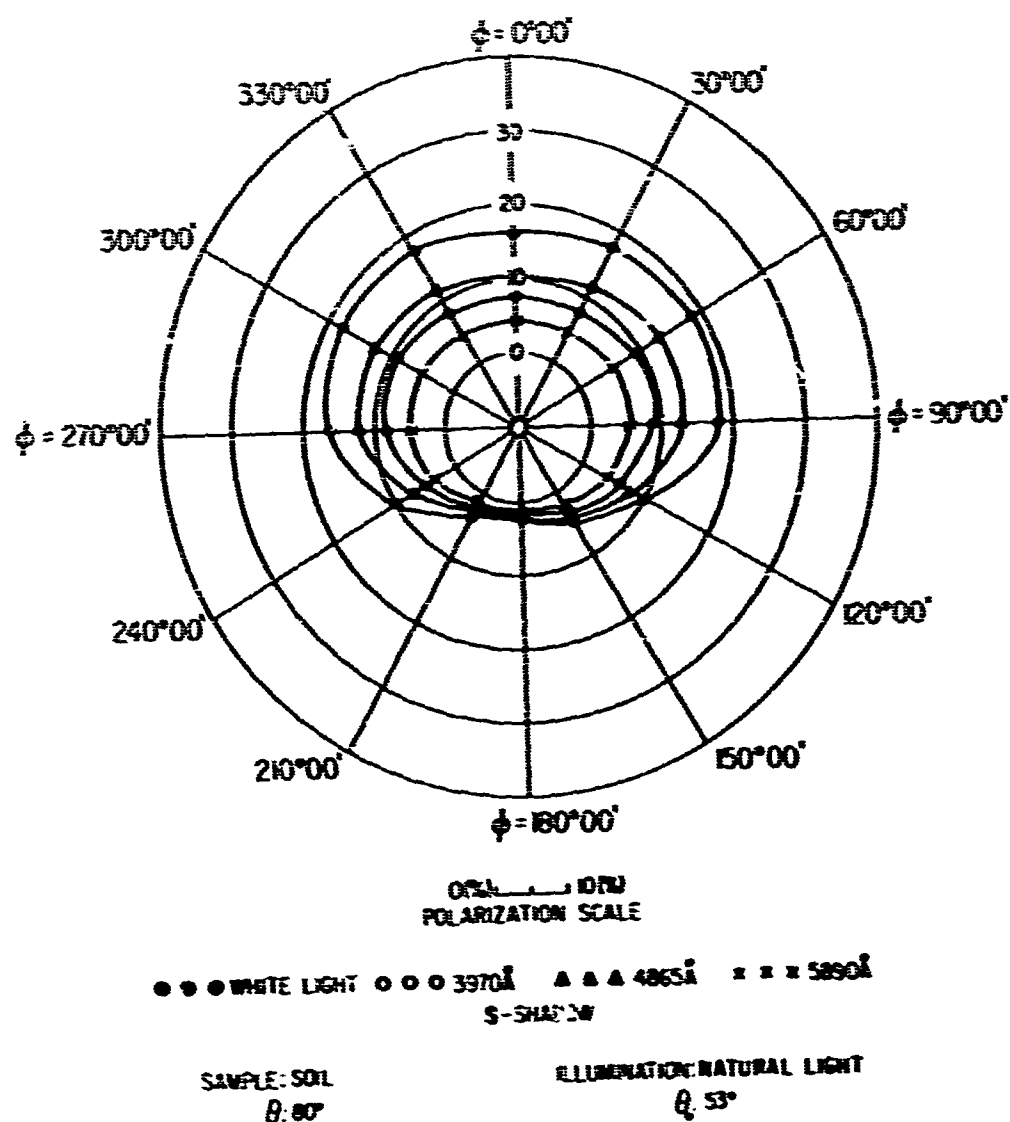


FIG. 194 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 6.32 + 2.96 \cos \phi - 1.90 \cos 2\phi - 0.43 \cos 3\phi + 0.20 \cos 4\phi + 0.07 \cos 5\phi \\ + 0.15 \cos 6\phi + 0.38 \sin \phi + 0.32 \sin 2\phi + 0.09 \sin 3\phi + 0.08 \sin 4\phi - 0.32 \sin 5\phi$$

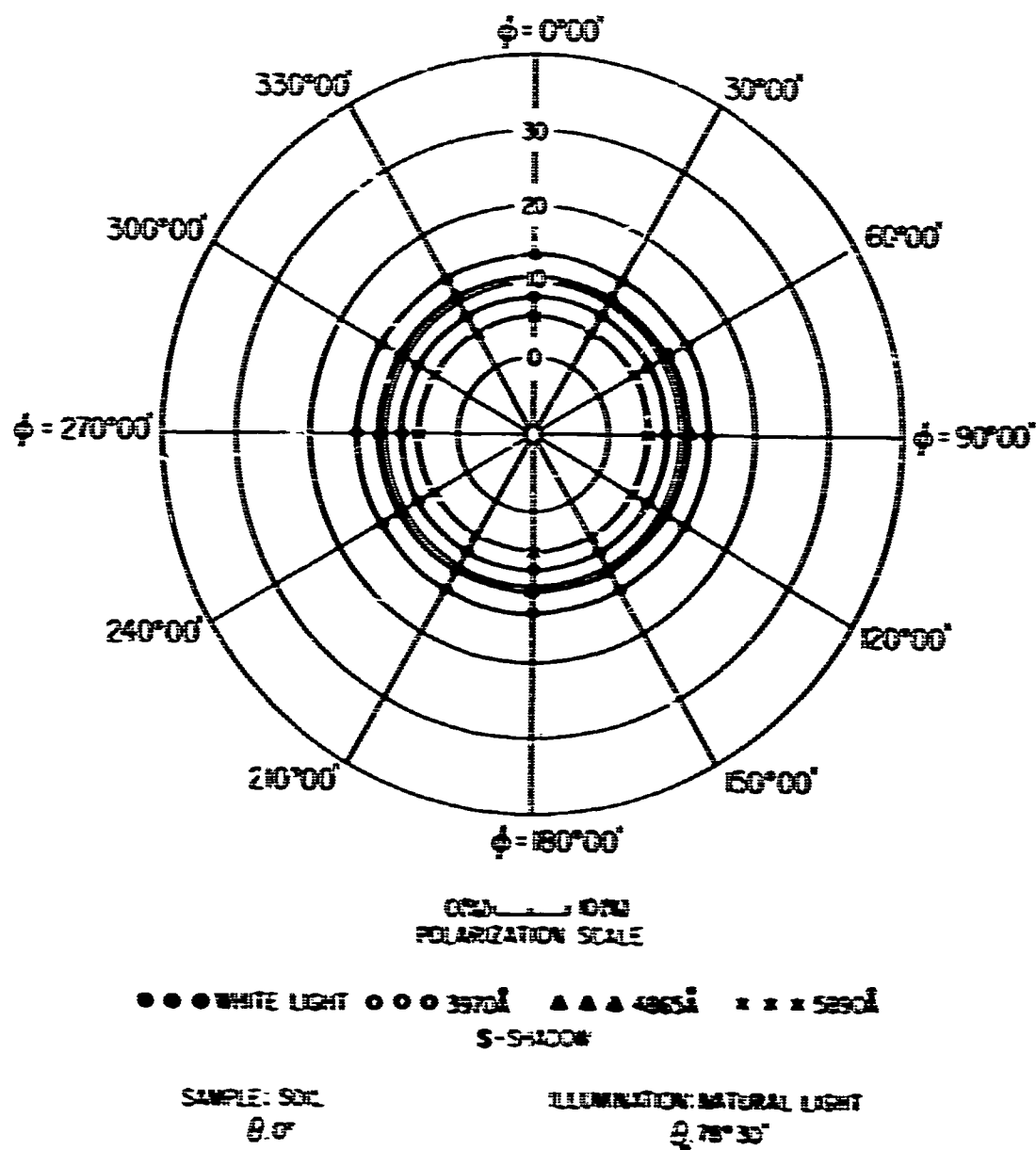


FIG. 195 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

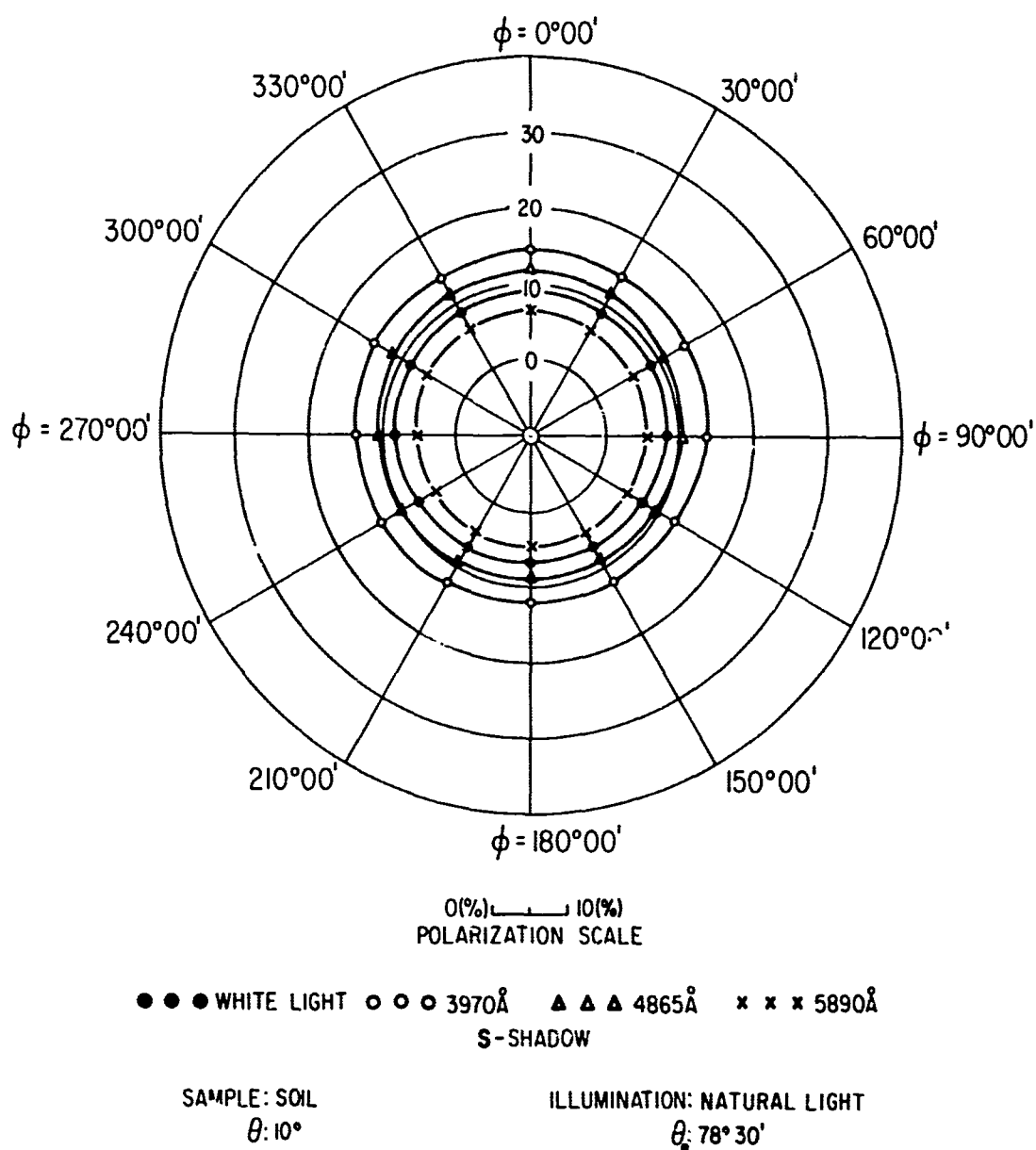
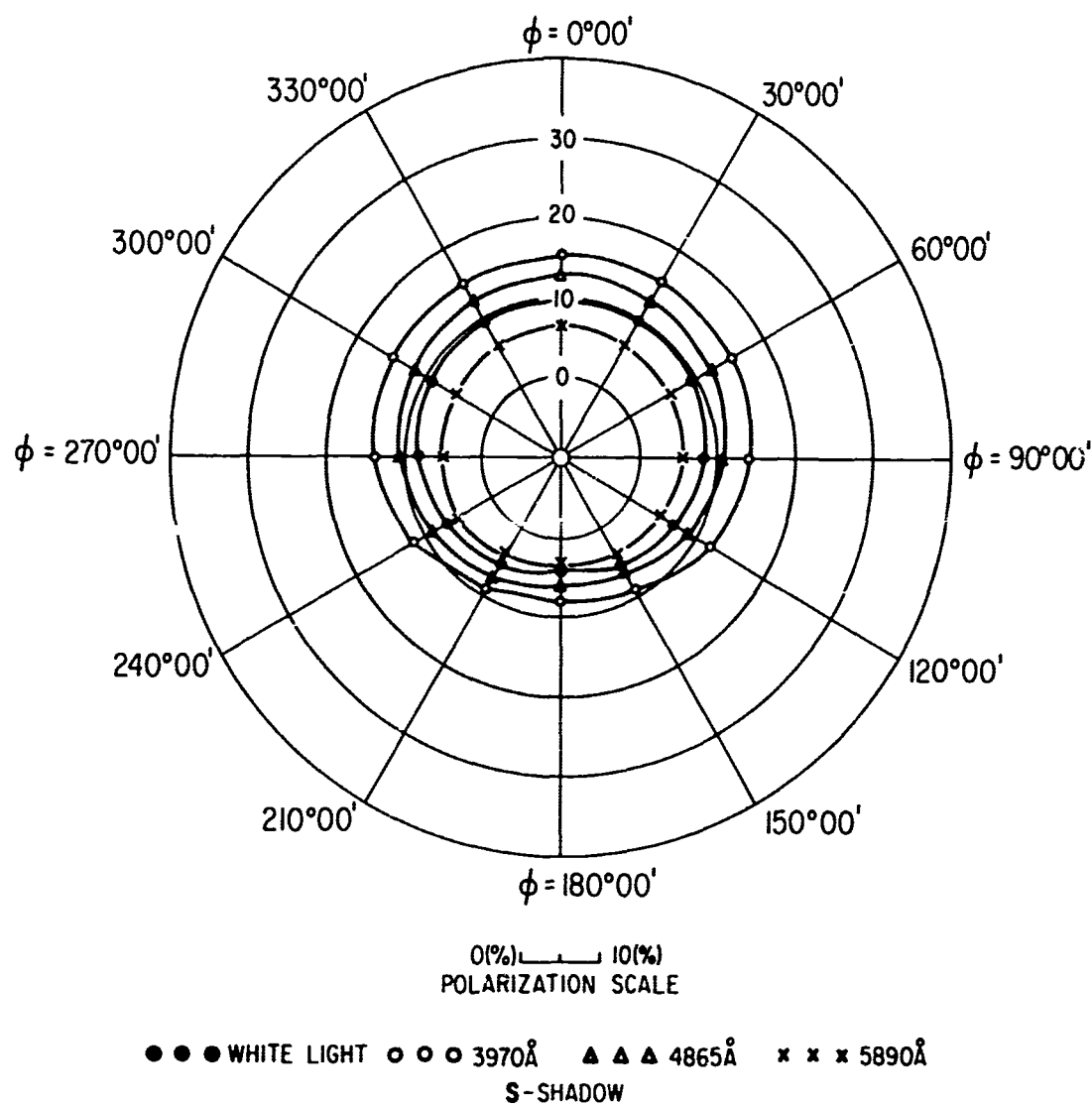


FIG.196 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 7.88 + 1.34 \cos \varphi - 0.06 \cos 2\varphi + 0.02 \cos 3\varphi + 0.02 \cos 4\varphi - 0.16 \cos 5\varphi \\
 & + 0.02 \cos 6\varphi - 0.03 \sin \varphi + 0.13 \sin 2\varphi - 0.03 \sin 3\varphi + 0.01 \sin 4\varphi - 0.15 \sin 5\varphi
 \end{aligned}$$



SAMPLE: SOIL
 $\theta: 20^{\circ}$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 78^{\circ}30'$

FIG. 197 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 7.69 + 2.04 \cos \varphi - 0.92 \cos 2\varphi + 0.05 \cos 3\varphi - 0.55 \cos 4\varphi - 0.50 \cos 5\varphi \\
 & - 0.08 \cos 6\varphi + 0.27 \sin \varphi + 0.12 \sin 2\varphi + 0.03 \sin 3\varphi - 0.06 \sin 4\varphi - 0.00 \sin 5\varphi
 \end{aligned}$$

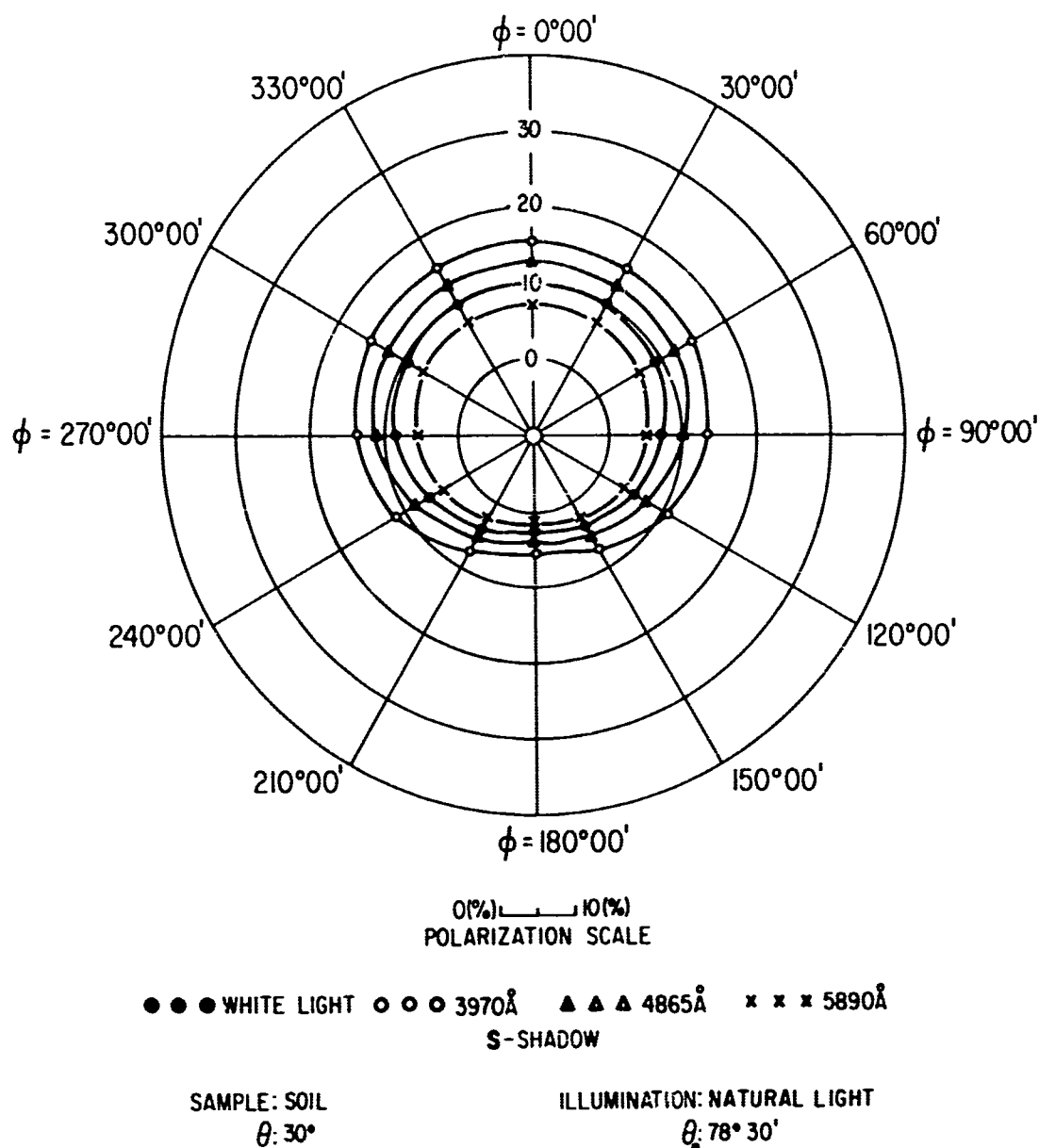
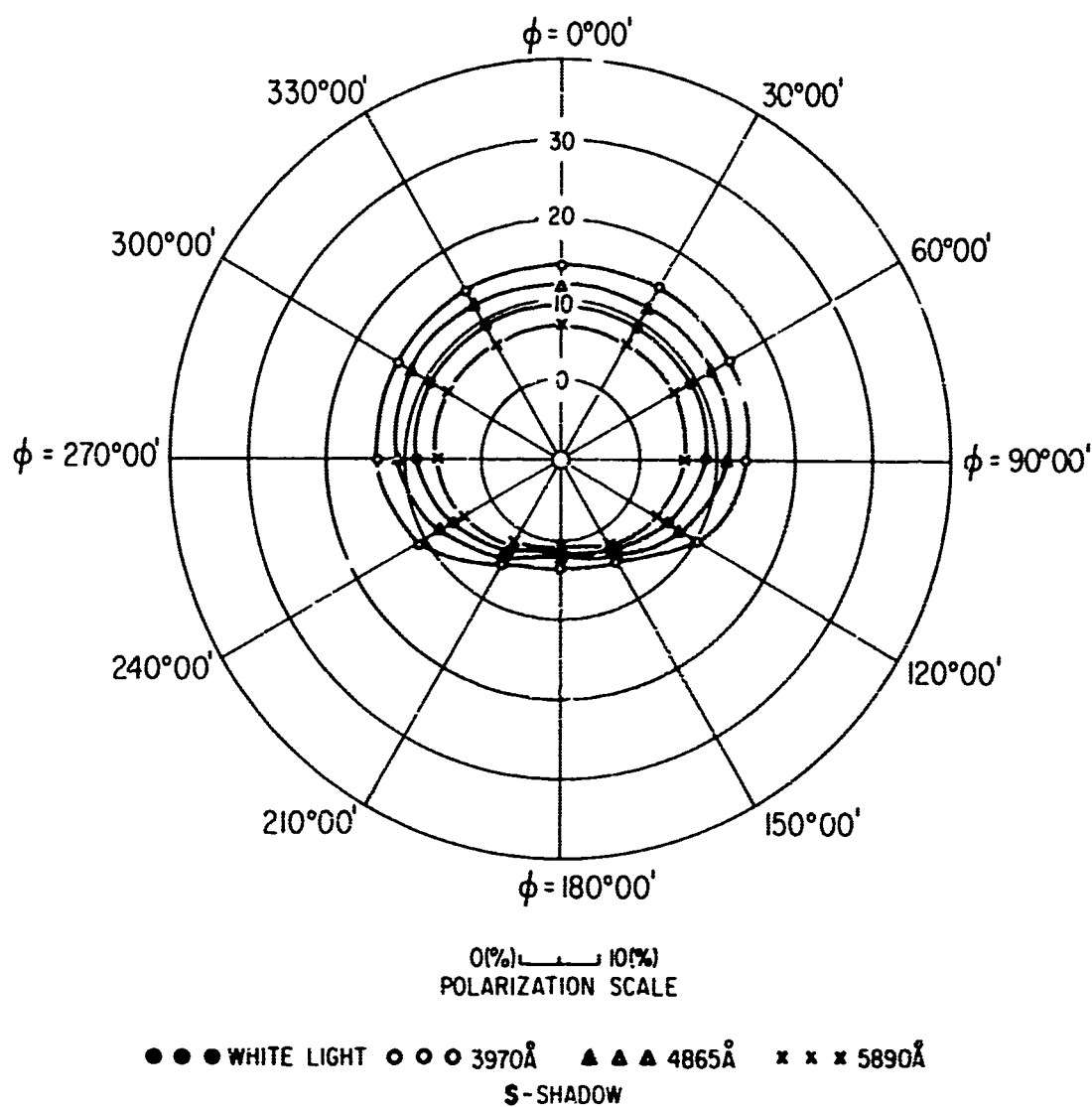


FIG. 198 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.96 + 3.24 \cos \varphi - 0.52 \cos 2\varphi + 0.25 \cos 3\varphi - 0.18 \cos 4\varphi - 0.08 \cos 5\varphi \\
 & - 0.22 \cos 6\varphi - 0.30 \sin \varphi - 0.09 \sin 2\varphi - 0.13 \sin 3\varphi - 0.09 \sin 4\varphi - 0.08 \sin 5\varphi
 \end{aligned}$$



SAMPLE: SOIL
 $\theta: 40^{\circ}$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 78^{\circ}30'$

FIG. 199 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
 OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 6.82 + 3.78 \cos \varphi - 1.38 \cos 2\varphi + 0.18 \cos 3\varphi + 0.05 \cos 4\varphi + 0.09 \cos 5\varphi \\
 & - 0.09 \cos 6\varphi - 0.08 \sin \varphi + 0.09 \sin 2\varphi + 0.00 \sin 3\varphi - 0.09 \sin 4\varphi - 0.02 \sin 5\varphi
 \end{aligned}$$

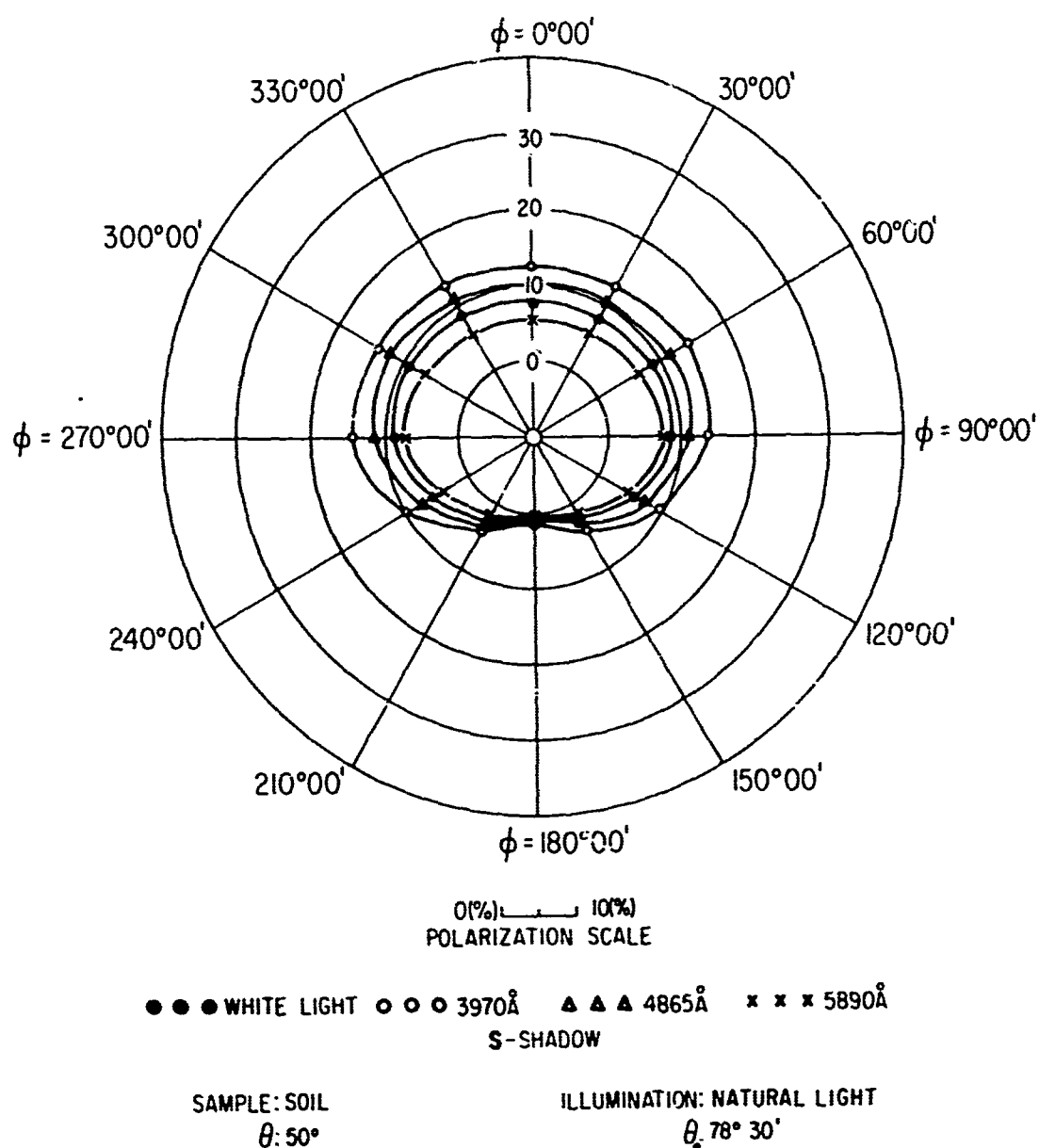
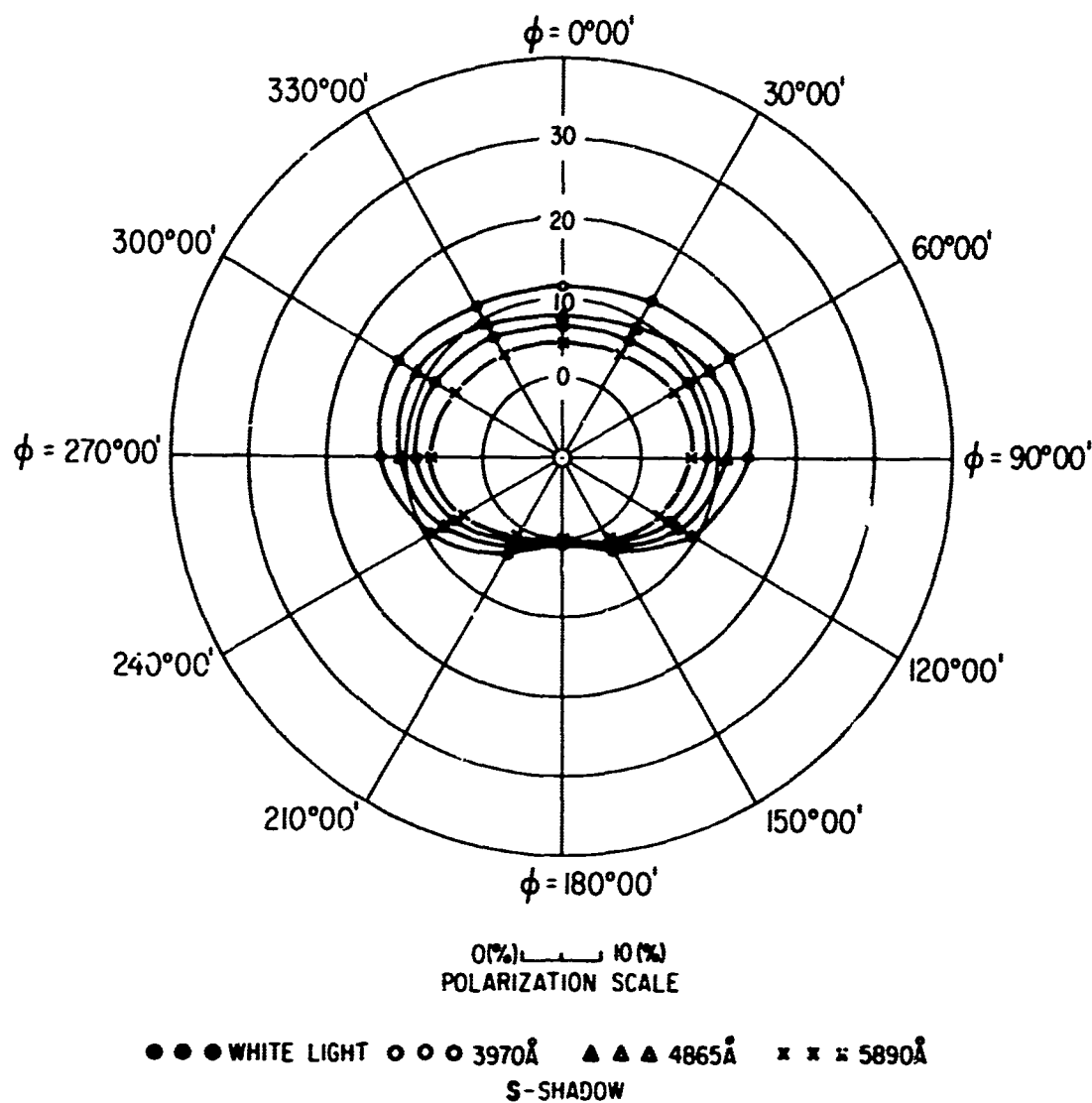


FIG.200 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 6.32 + 3.57 \cos \varphi - 2.28 \cos 2\varphi + 0.18 \cos 3\varphi - 0.08 \cos 4\varphi + 0.15 \cos 5\varphi \\ - 0.15 \cos 6\varphi - 0.22 \sin \varphi - 0.05 \sin 2\varphi - 0.10 \sin 3\varphi - 0.08 \sin 4\varphi - 0.08 \sin 5\varphi$$



SAMPLE: SOIL
 $\theta: 60^\circ$

ILLUMINATION: NATURAL LIGHT
 $\theta_i: 78^\circ 30'$

FIG.201 POLAR DIAGRAM SHOWING AZ.MUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 5.86 + 3.07 \cos \varphi - 2.58 \cos 2\varphi - 0.12 \cos 3\varphi - 0.22 \cos 4\varphi - 0.05 \cos 5\varphi \\ - 0.15 \cos 6\varphi + 0.05 \sin \varphi - 0.16 \sin 2\varphi - 0.13 \sin 3\varphi - 0.02 \sin 4\varphi - 0.09 \sin 5\varphi$$

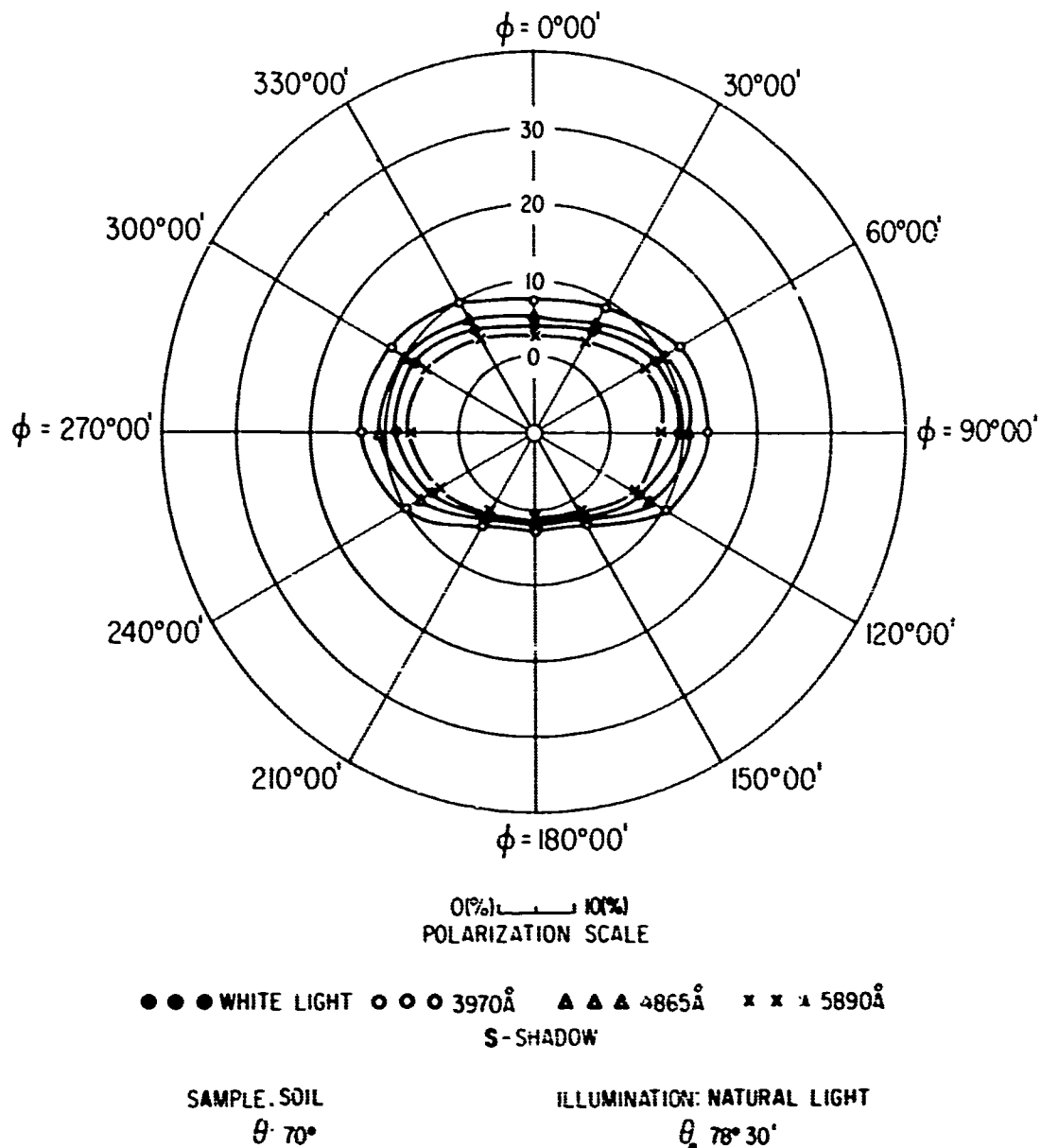


FIG.202 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.71 + 1.82 \cos \phi - 3.20 \cos 2\phi - 0.25 \cos 3\phi + 0.07 \cos 4\phi - 0.32 \cos 5\phi \\
 & + 0.60 \cos 6\phi + 0.46 \sin \phi - 0.23 \sin 2\phi - 0.22 \sin 3\phi + 0.17 \sin 4\phi - 0.12 \sin 5\phi
 \end{aligned}$$

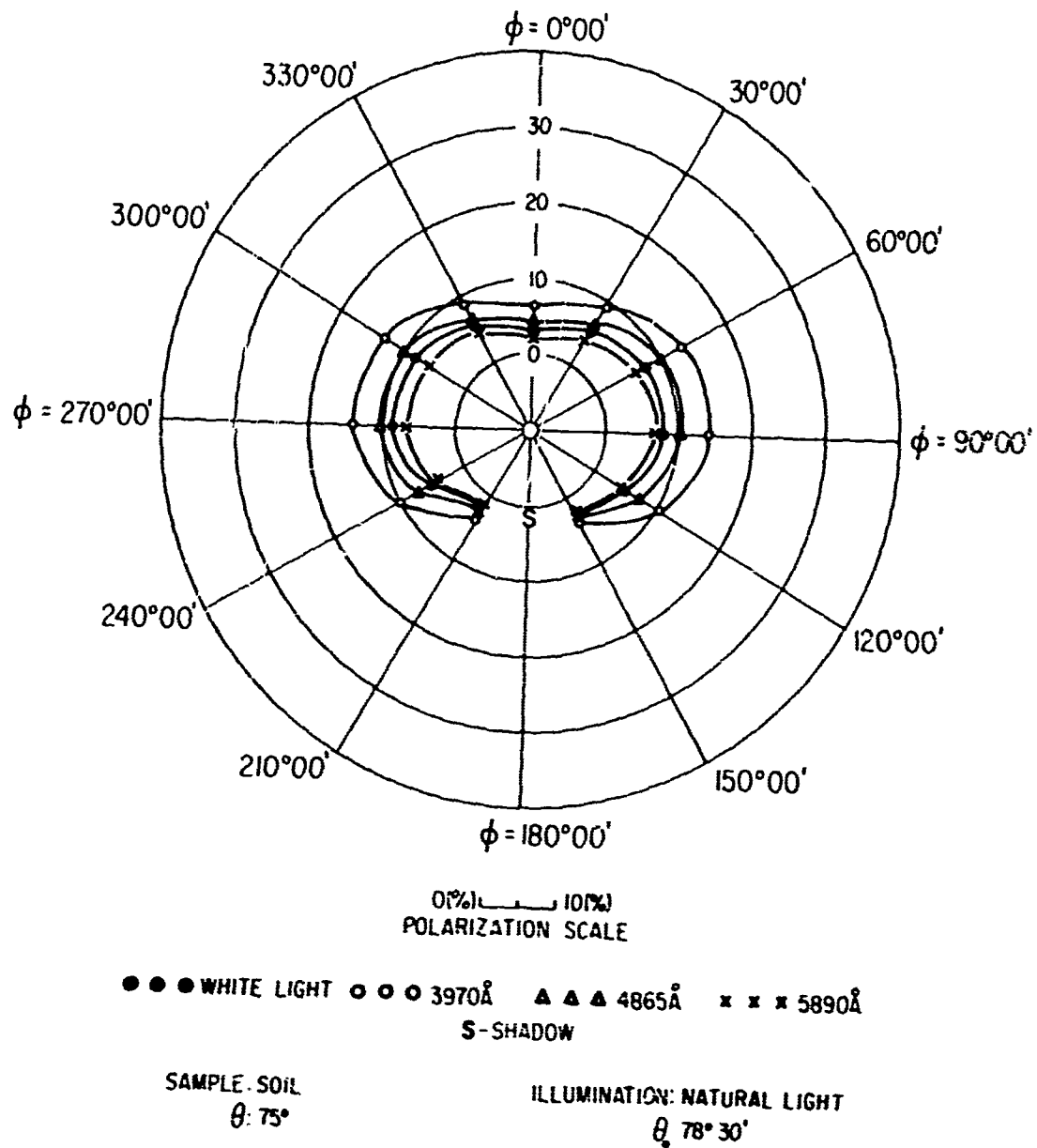


FIG. 203 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 5.12 + 1.82 \cos \phi - 2.77 \cos 2\phi - 0.92 \cos 3\phi + 0.30 \cos 4\phi - 0.15 \cos 5\phi \\
 & - 0.22 \cos 6\phi - 0.29 \sin \phi - 0.09 \sin 2\phi + 0.17 \sin 3\phi - 0.08 \sin 4\phi + 0.06 \sin 5\phi
 \end{aligned}$$

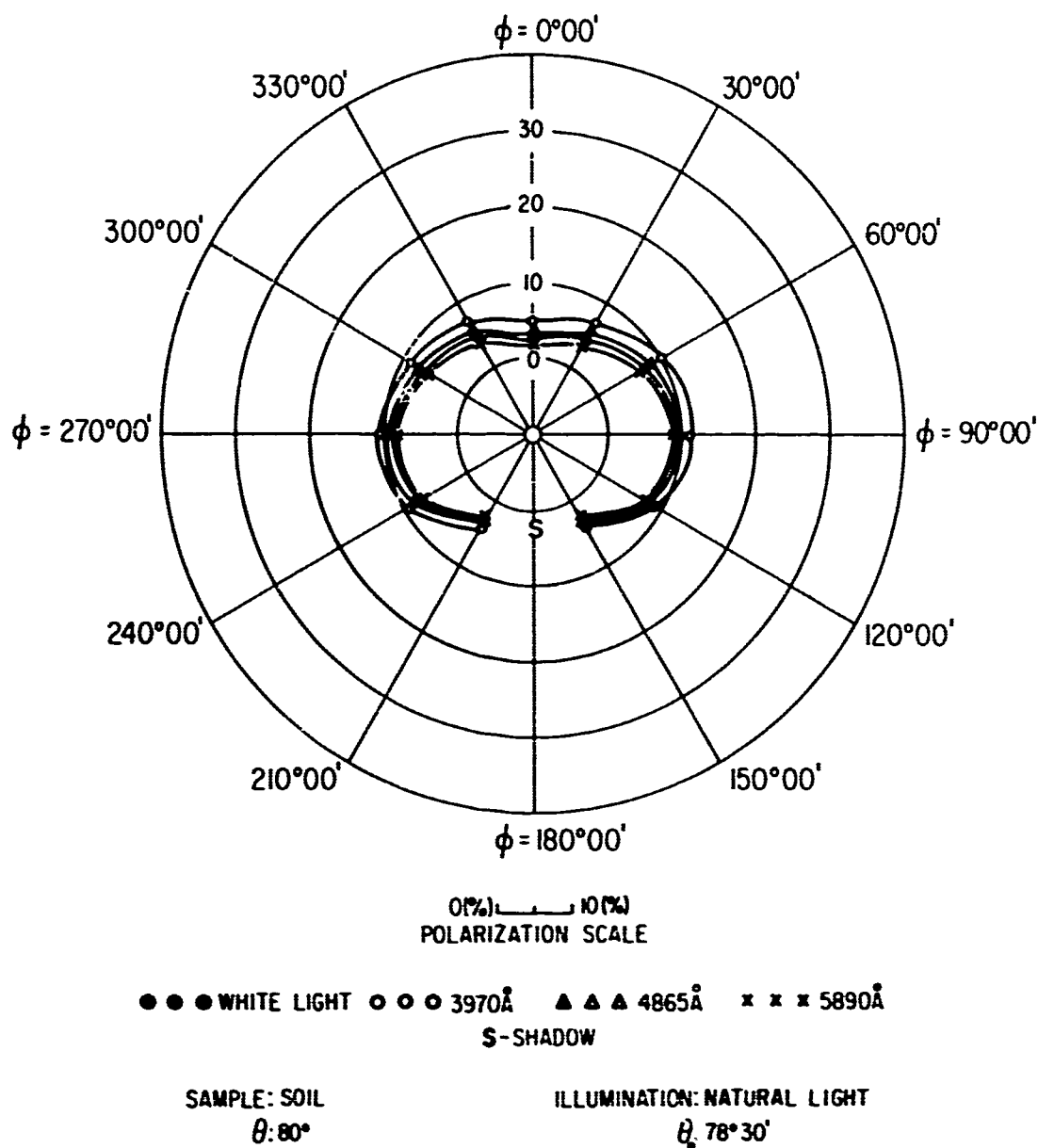


FIG.204 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 5.38 + 0.62 \cos \varphi - 3.32 \cos 2\varphi + 0.10 \cos 3\varphi - 0.02 \cos 4\varphi - 0.47 \cos 5\varphi \\ + 0.03 \cos 6\varphi - 0.39 \sin \varphi - 0.30 \sin 2\varphi - 0.13 \sin 3\varphi - 0.28 \sin 4\varphi - 0.39 \sin 5\varphi$$

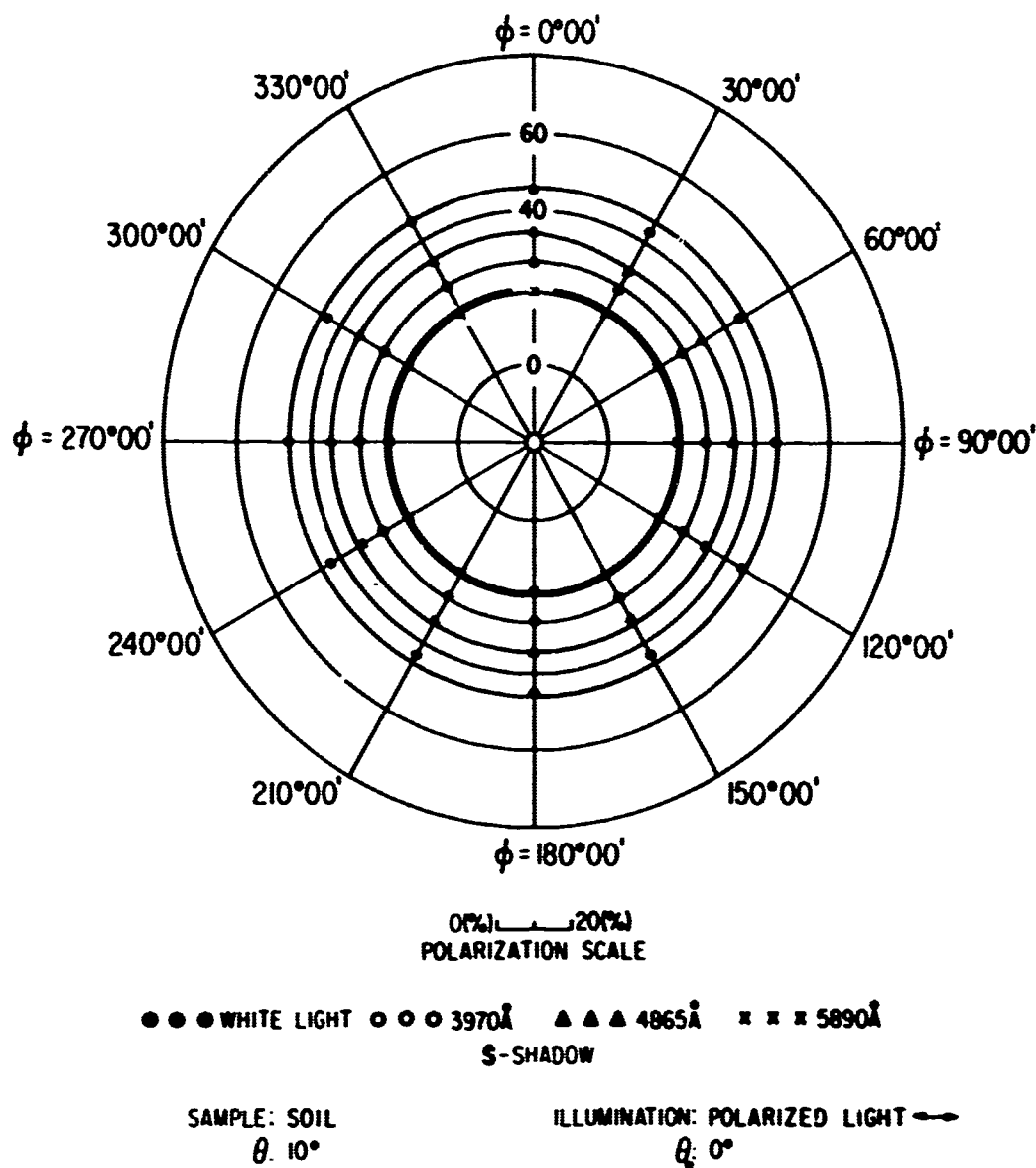


FIG. 205. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 26.36 - 0.40 \cos \varphi - 0.02 \cos 2\varphi + 0.00 \cos 3\varphi + 0.22 \cos 4\varphi - 0.10 \cos 5\varphi \\
 & + 0.08 \cos 6\varphi - 0.17 \sin \varphi - 0.06 \sin 2\varphi - 0.05 \sin 3\varphi - 0.06 \sin 4\varphi - 0.23 \sin 5\varphi
 \end{aligned}$$

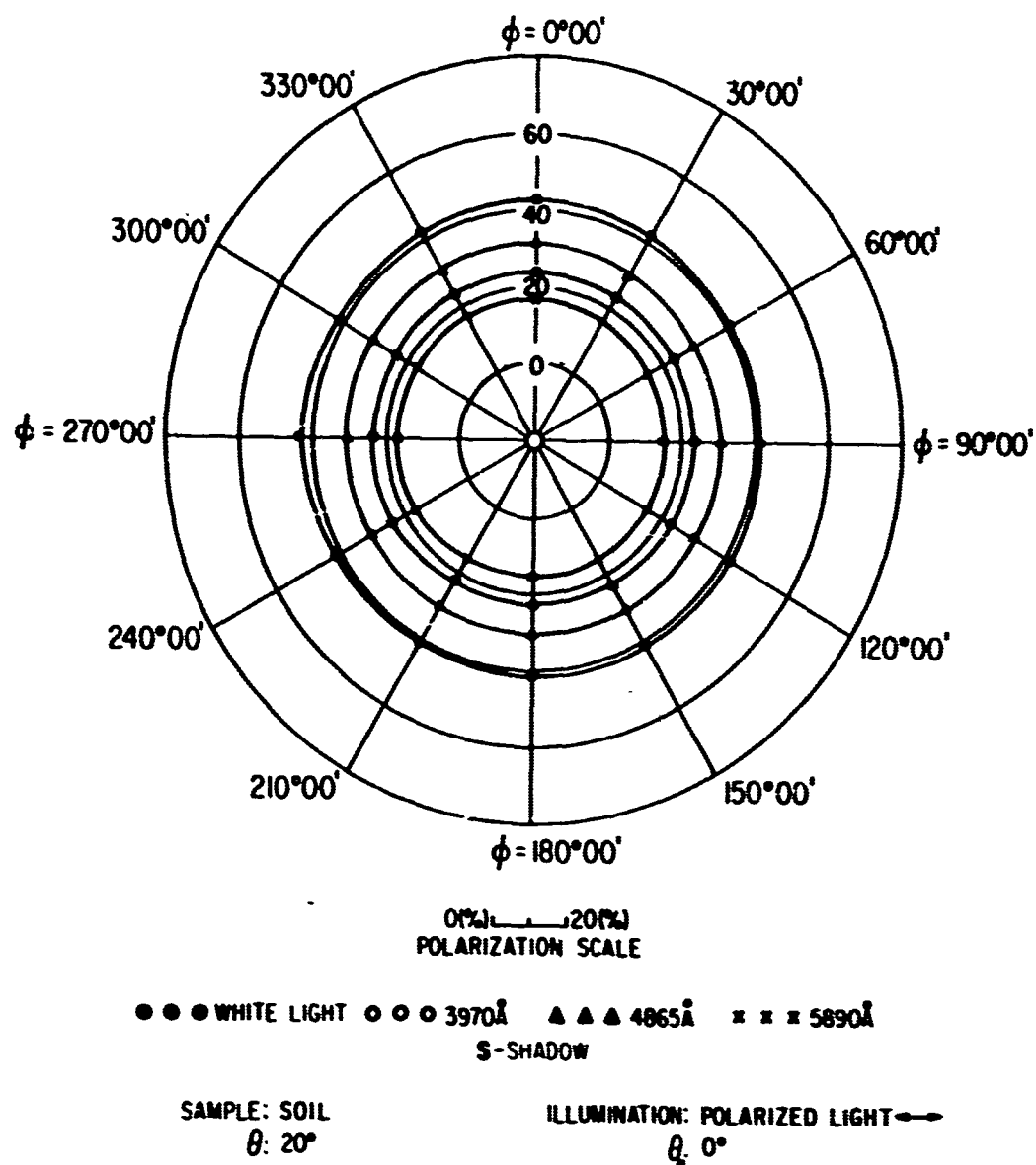


FIG. 206. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 23.27 - 0.01 \cos \varphi - 0.63 \cos 2\varphi - 0.30 \cos 3\varphi + 0.53 \cos 4\varphi + 0.11 \cos 5\varphi \\
 & - 0.27 \cos 6\varphi - 0.04 \sin \varphi - 0.32 \sin 2\varphi - 0.10 \sin 3\varphi - 1.41 \sin 4\varphi - 0.16 \sin 5\varphi
 \end{aligned}$$

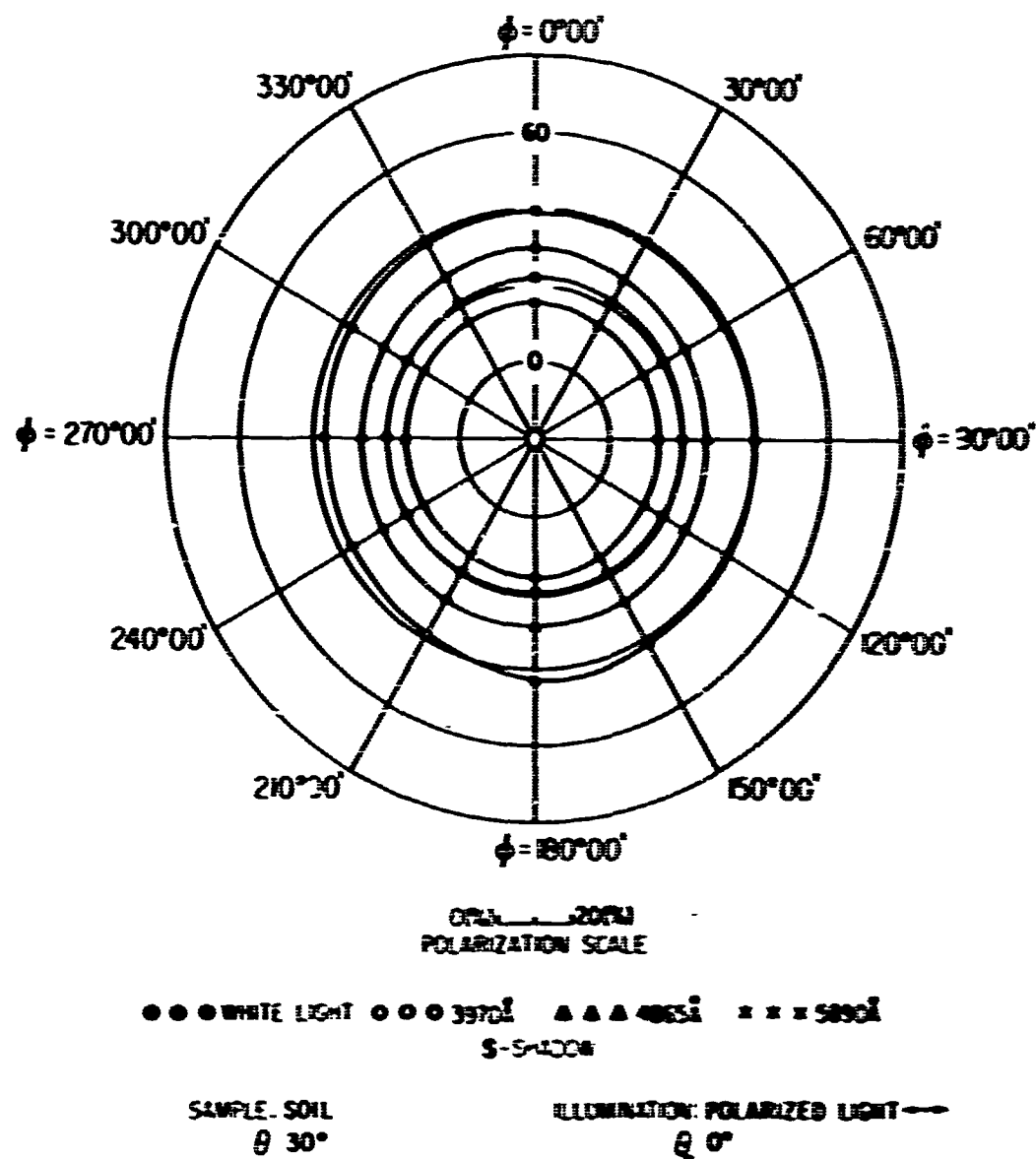


FIG. 207. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 20.72 - 0.14 \cos \phi + 1.39 \cos 2\phi + 0.00 \cos 3\phi + 0.41 \cos 4\phi - 0.06 \cos 5\phi \\ - 0.03 \cos 6\phi + 0.10 \sin \phi - 0.10 \sin 2\phi - 0.13 \sin 3\phi - 0.16 \sin 4\phi - 0.08 \sin 5\phi$$

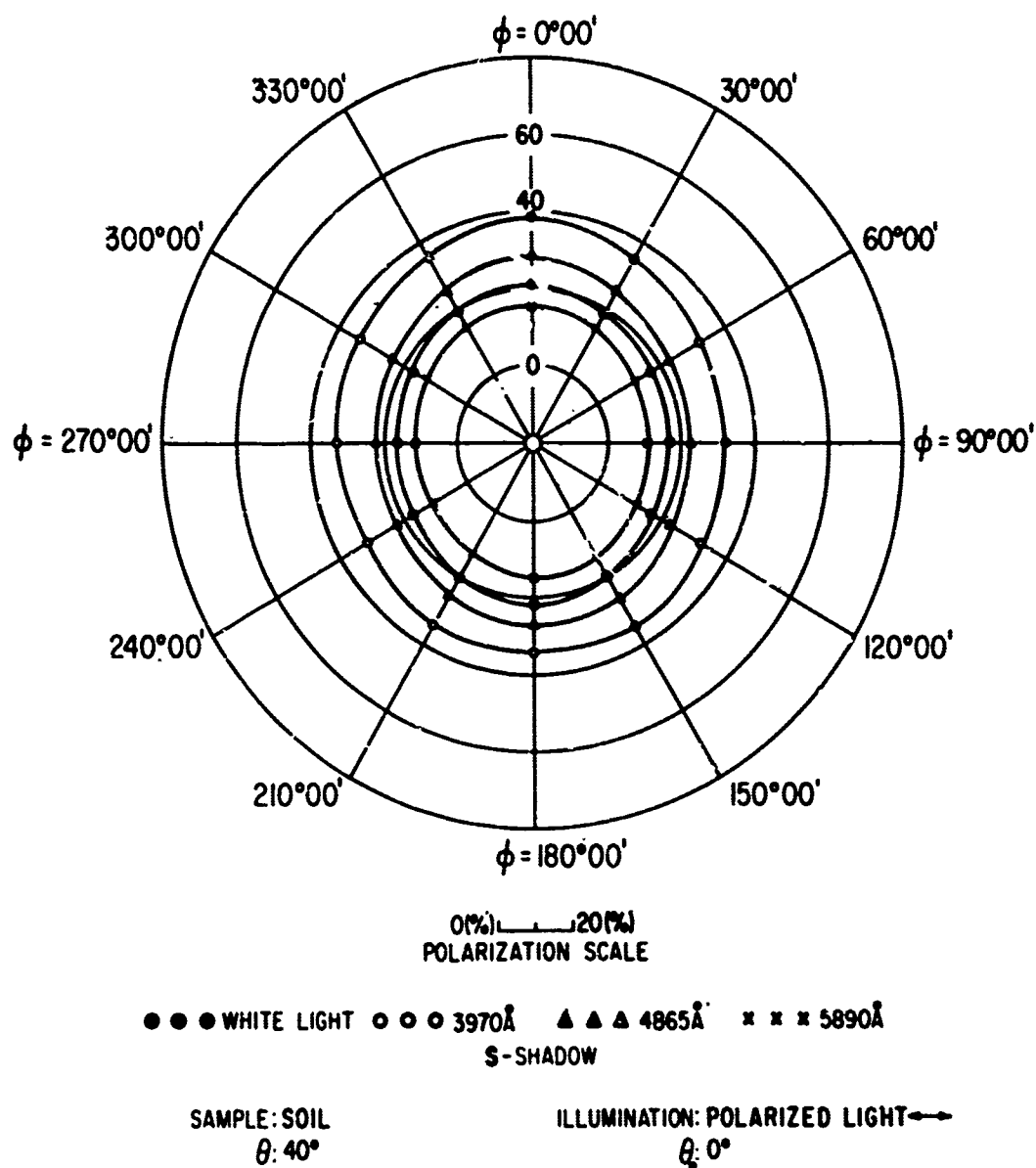


FIG. 208. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 18.61 - 0.45 \cos \varphi + 2.51 \cos 2\varphi - 0.18 \cos 3\varphi + 0.54 \cos 4\varphi + 0.13 \cos 5\varphi \\ + 0.08 \cos 6\varphi + 0.01 \sin \varphi - 0.22 \sin 2\varphi + 0.03 \sin 3\varphi + 0.16 \sin 4\varphi - 0.08 \sin 5\varphi$$

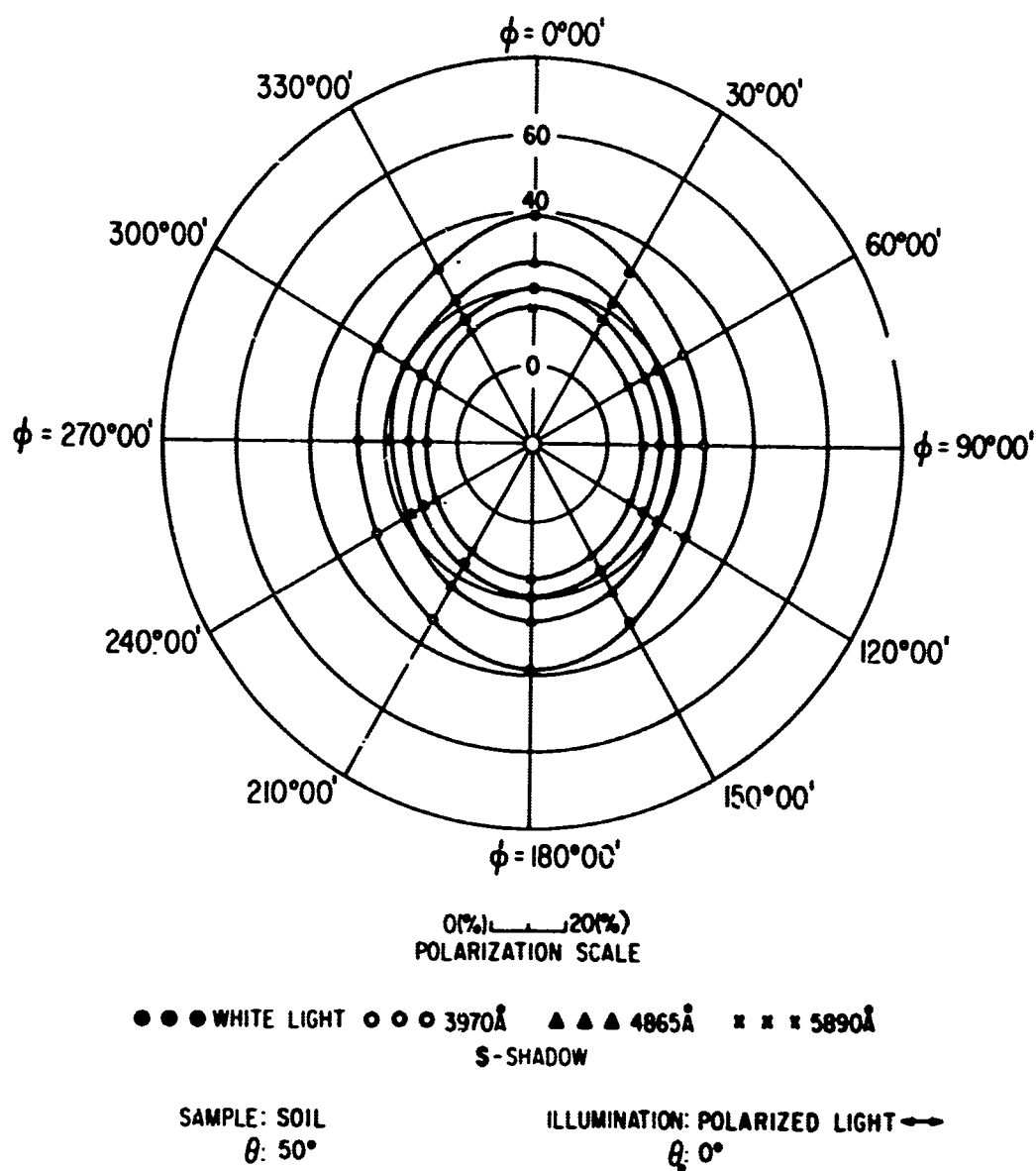


FIG. 209. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 13.10 + 0.10 \cos \varphi + 6.54 \cos 2\varphi + 0.05 \cos 3\varphi + 2.58 \cos 4\varphi + 0.05 \cos 5\varphi \\
 & - 1.63 \cos 6\varphi - 0.23 \sin \varphi - 1.17 \sin 2\varphi - 0.08 \sin 3\varphi - 0.97 \sin 4\varphi + 0.20 \sin 5\varphi
 \end{aligned}$$

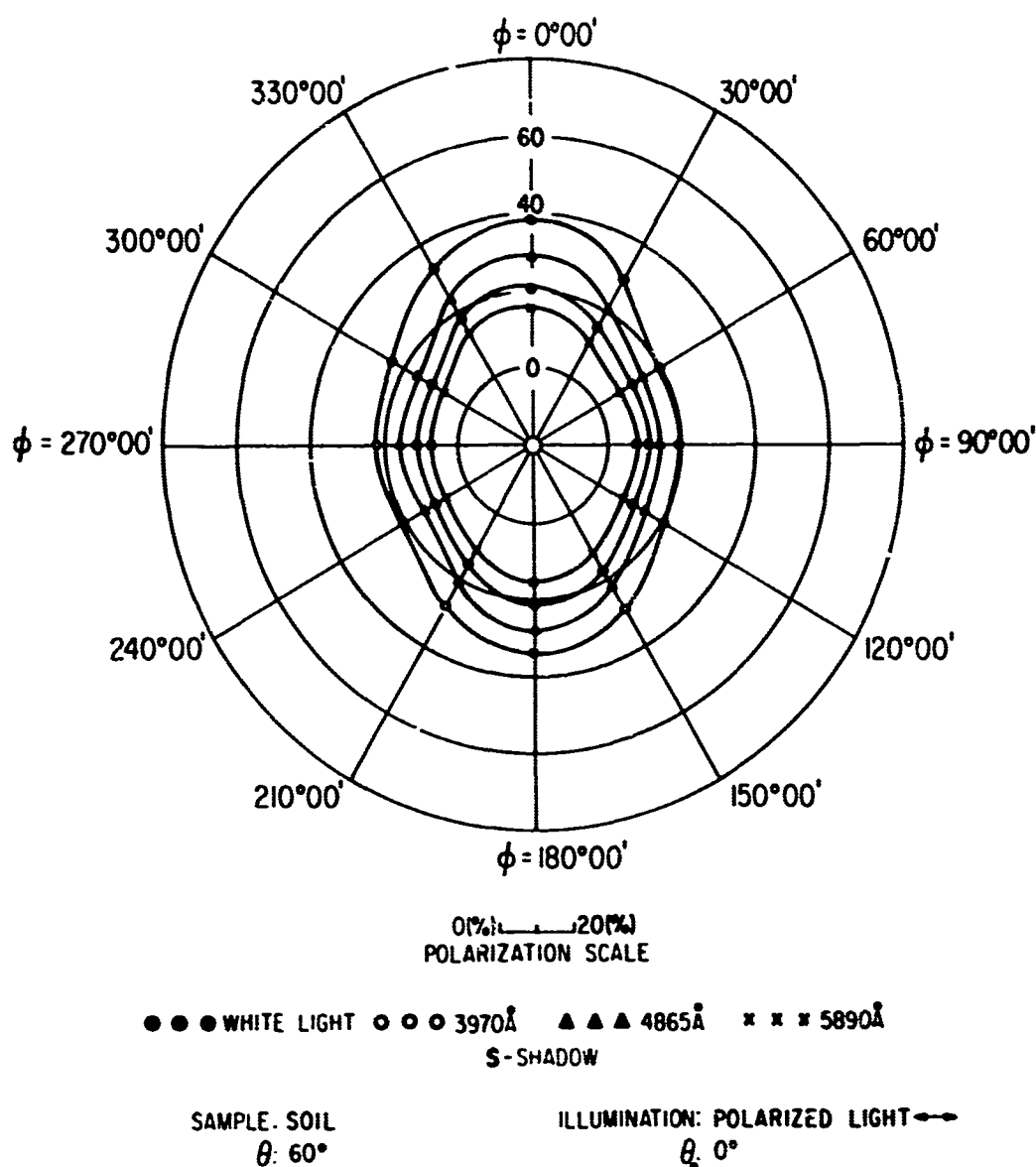


FIG. 210. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 13.48 - 0.07 \cos \varphi + 5.05 \cos 2\varphi - 0.13 \cos 3\varphi + 1.80 \cos 4\varphi - 0.04 \cos 5\varphi \\
 & - 0.60 \cos 6\varphi - 0.14 \sin \varphi - 0.58 \sin 2\varphi - 0.13 \sin 3\varphi - 0.38 \sin 4\varphi + 3.05 \sin 5\varphi
 \end{aligned}$$

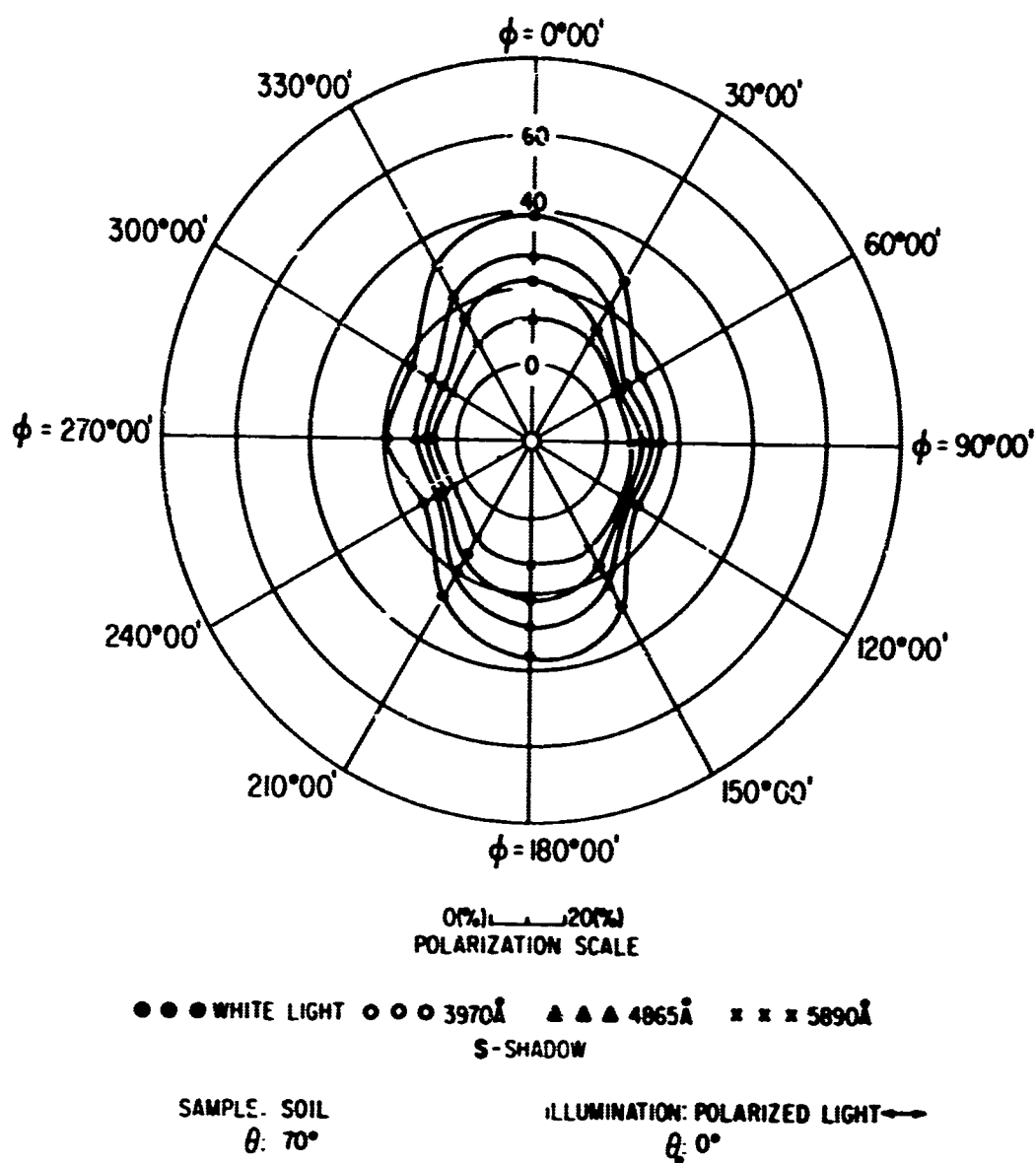


FIG. 211. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 12.93 - 0.06 \cos \phi + 6.69 \cos 2\phi + 0.27 \cos 3\phi + 2.54 \cos 4\phi - 0.20 \cos 5\phi \\
 & - 1.13 \cos 6\phi - 0.11 \sin \phi - 1.11 \sin 2\phi - 0.43 \sin 3\phi - 0.59 \sin 4\phi + 0.12 \sin 5\phi
 \end{aligned}$$

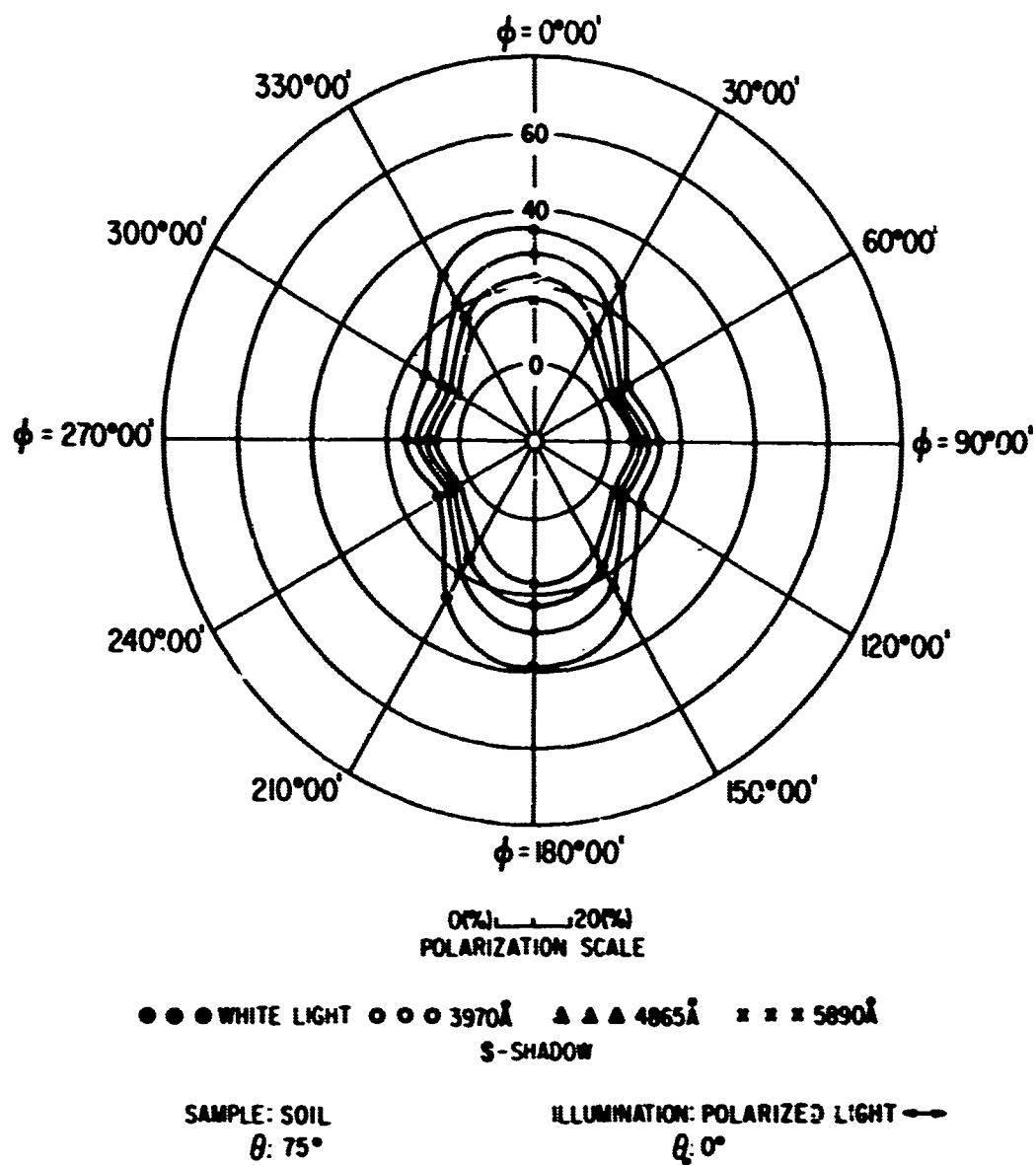


FIG. 212. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 12.54 - 0.06 \cos \varphi + 7.47 \cos 2\varphi + 0.27 \cos 3\varphi + 3.28 \cos 4\varphi - 0.15 \cos 5\varphi \\
 & - 2.08 \cos 6\varphi + 0.01 \sin \varphi - 1.47 \sin 2\varphi - 0.04 \sin 3\varphi - 0.98 \sin 4\varphi + 0.04 \sin 5\varphi
 \end{aligned}$$

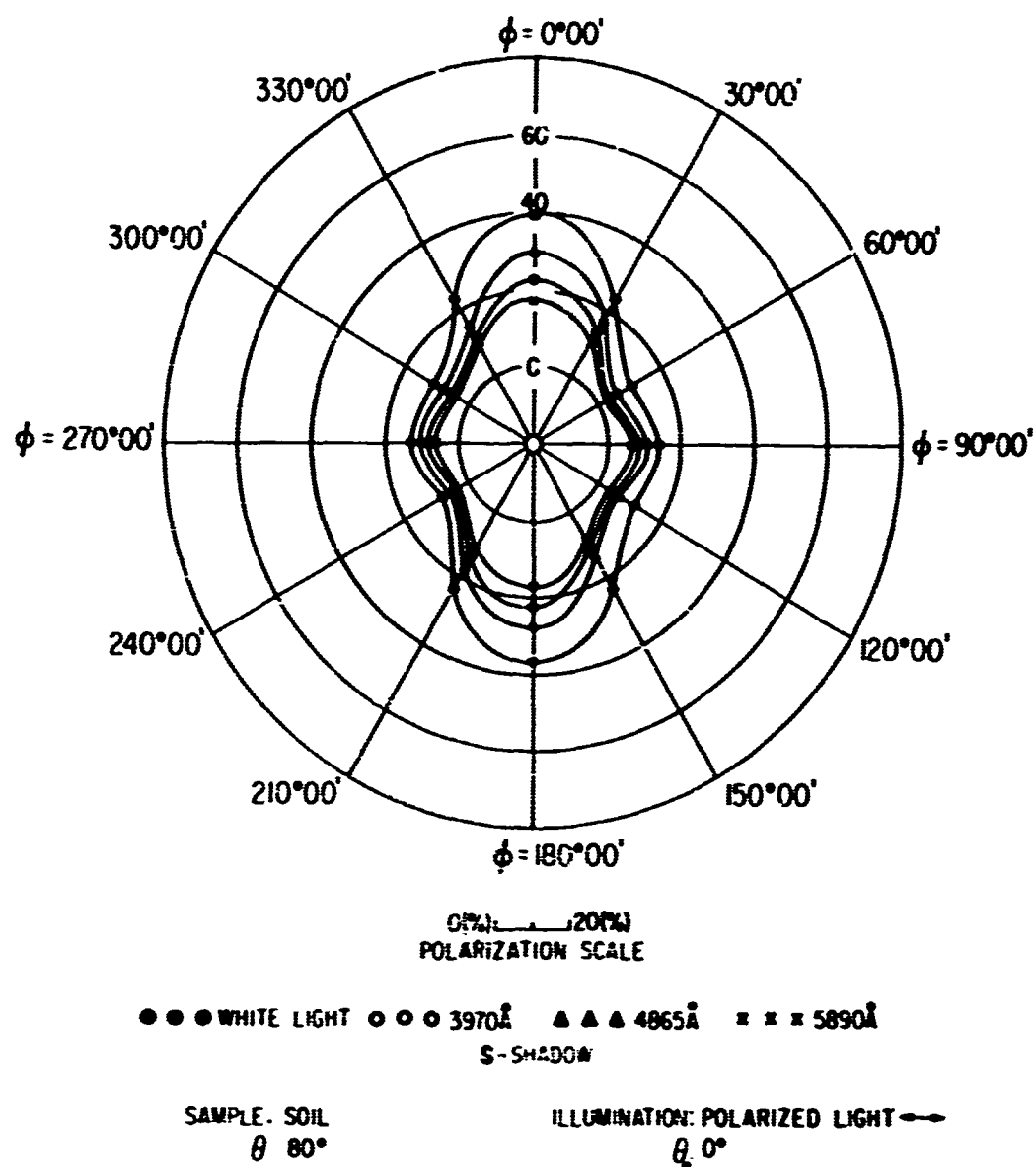


FIG. 213. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 12.71 - 0.20 \cos \phi + 7.90 \cos 2\phi + 0.53 \cos 3\phi + 3.60 \cos 4\phi - 0.34 \cos 5\phi \\
 & - 2.22 \cos 6\phi + 0.20 \sin \phi - 1.86 \sin 2\phi - 0.05 \sin 3\phi - 0.65 \sin 4\phi - 0.37 \sin 5\phi
 \end{aligned}$$

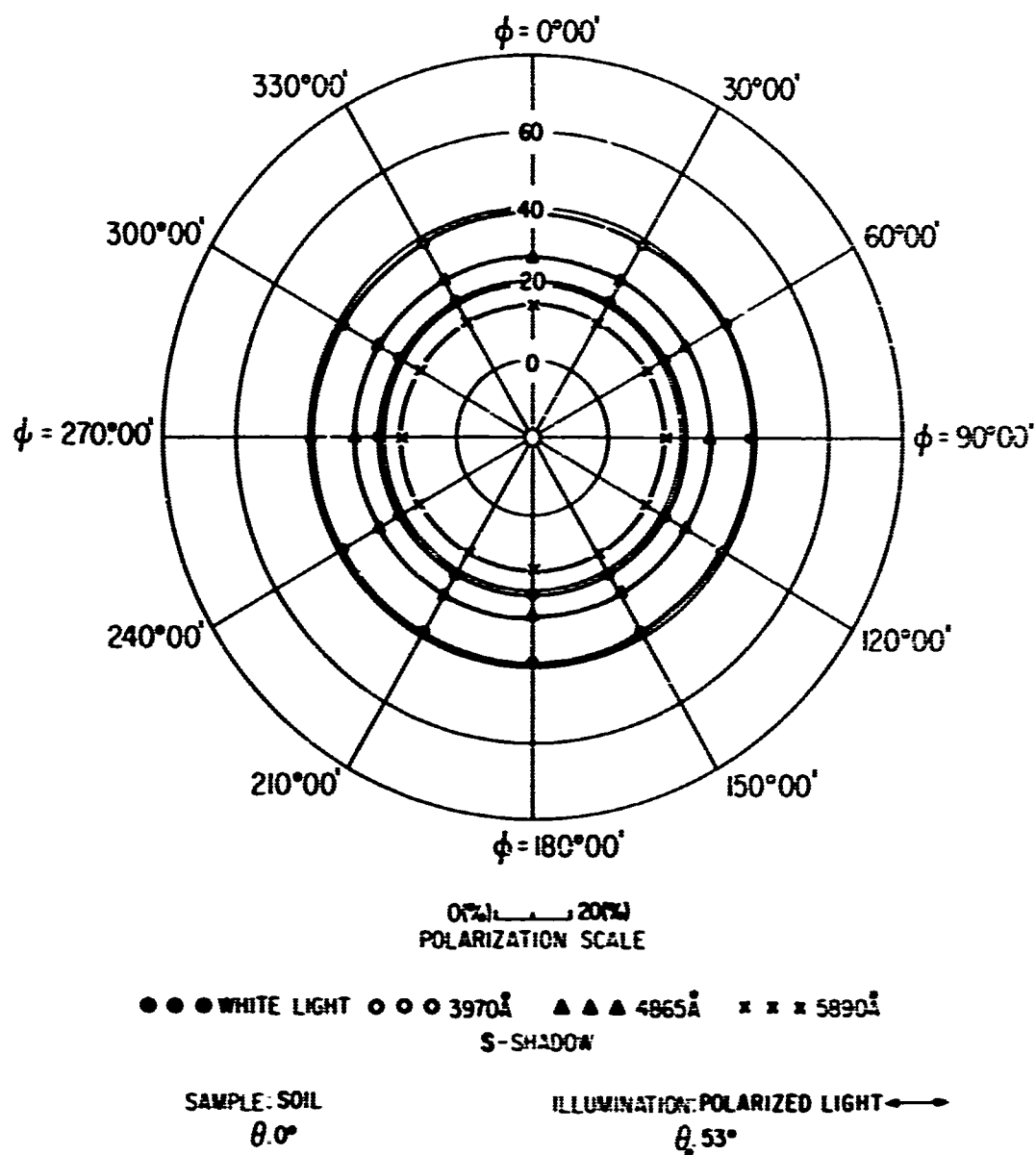


FIG.214 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

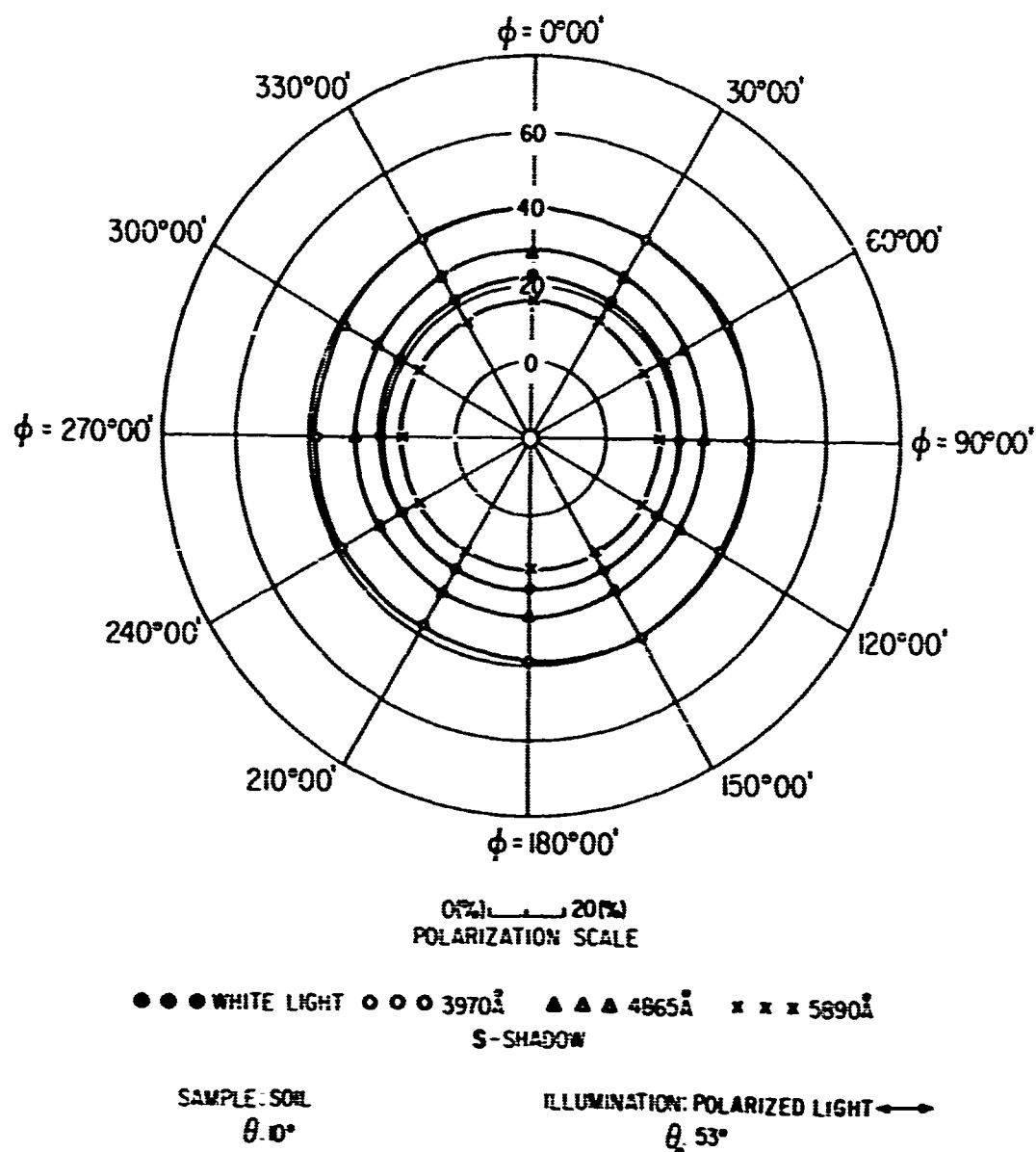


FIG. 215 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 20.5 + 1.16 \cos \phi + 0.51 \cos 2\phi - 0.05 \cos 3\phi - 0.01 \cos 4\phi + 0.04 \cos 5\phi \\
 & + 0.03 \cos 6\phi - 0.20 \sin \phi + 0.01 \sin 2\phi - 0.03 \sin 3\phi - 0.04 \sin 4\phi - 0.18 \sin 5\phi
 \end{aligned}$$

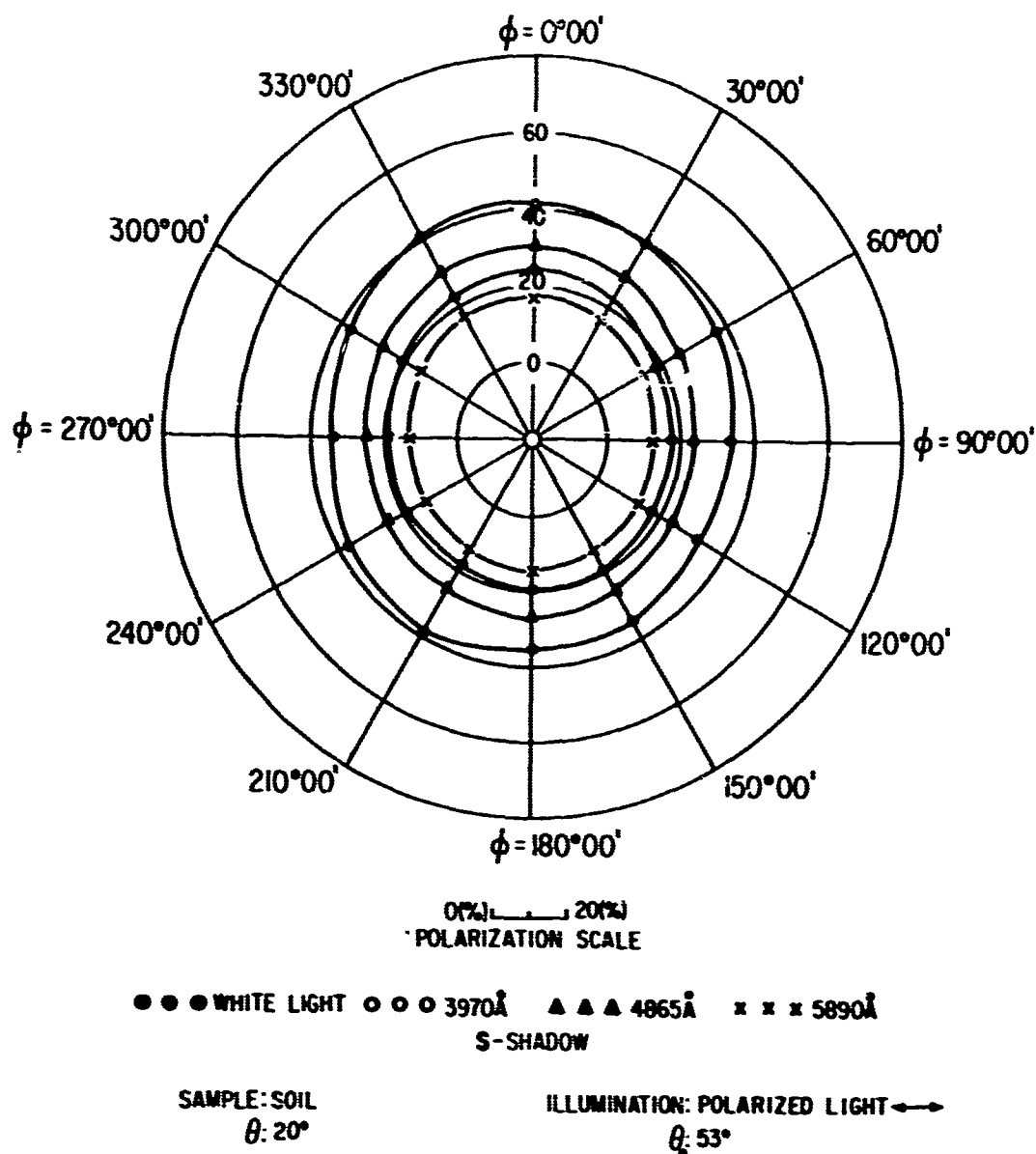


FIG. 216 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 19.58 + 2.08 \cos \varphi + 2.04 \cos 2\varphi + 0.38 \cos 3\varphi + 0.39 \cos 4\varphi + 0.32 \cos 5\varphi \\
 & + 3.17 \cos 6\varphi - 0.36 \sin \varphi - 0.16 \sin 2\varphi + 0.42 \sin 3\varphi - 0.44 \sin 4\varphi + 0.28 \sin 5\varphi
 \end{aligned}$$

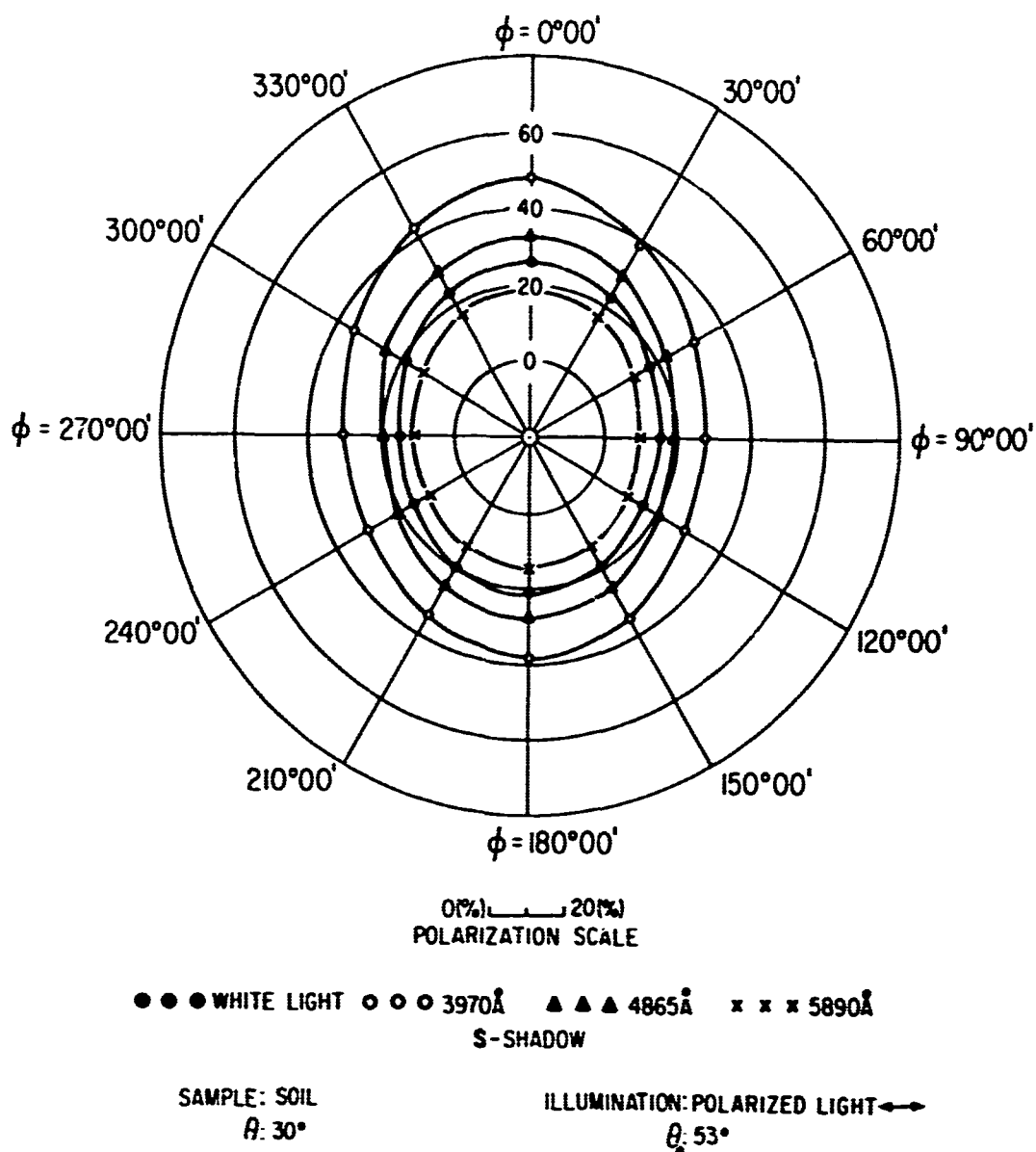


FIG.217 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 19.8 + 3.15 \cos \varphi + 3.52 \cos 2\varphi - 0.66 \cos 3\varphi + 0.20 \cos 4\varphi + 0.06 \cos 5\varphi \\
 & - 0.33 \cos 6\varphi - 1.85 \sin \varphi - 1.33 \sin 2\varphi - 0.03 \sin 3\varphi + 0.49 \sin 4\varphi - 0.03 \sin 5\varphi
 \end{aligned}$$

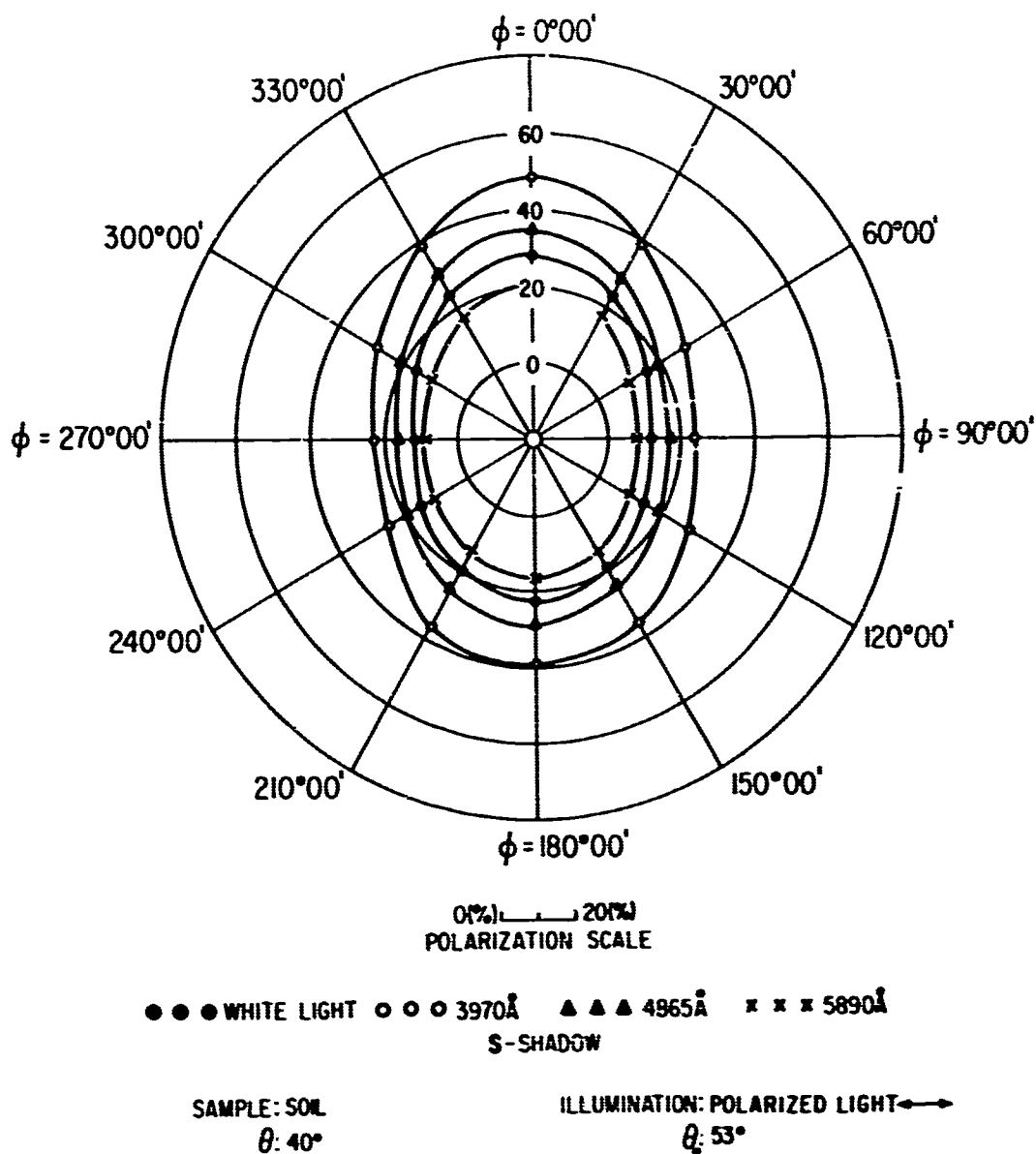


FIG. 218 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 18.21 + 2.49 \cos \phi + 6.83 \cos 2\phi + 0.23 \cos 3\phi + 0.12 \cos 4\phi - 0.08 \cos 5\phi \\
 & + 0.98 \cos 6\phi - 0.49 \sin \phi + 0.00 \sin 2\phi - 0.05 \sin 3\phi - 0.26 \sin 4\phi - 0.35 \sin 5\phi
 \end{aligned}$$

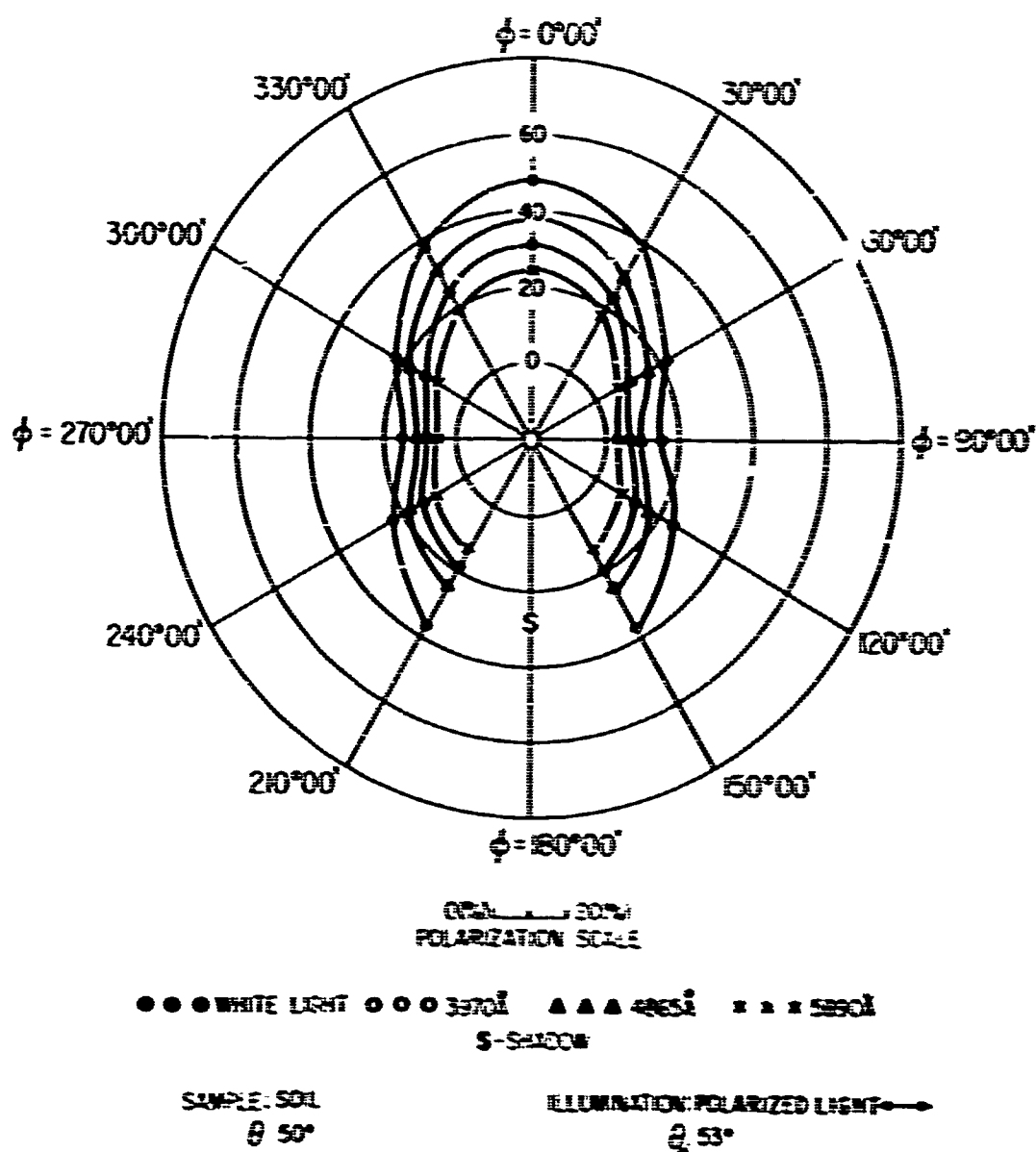


FIG 219 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 17.07 + 2.44 \cos \phi - 9.33 \cos 2\phi + 2.15 \cos 3\phi + 0.48 \cos 4\phi + 0.68 \cos 5\phi \\ + 0.43 \cos 6\phi + 0.56 \sin \phi - 0.46 \sin 2\phi - 0.08 \sin 3\phi + 0.11 \sin 4\phi + 0.13 \sin 5\phi$$

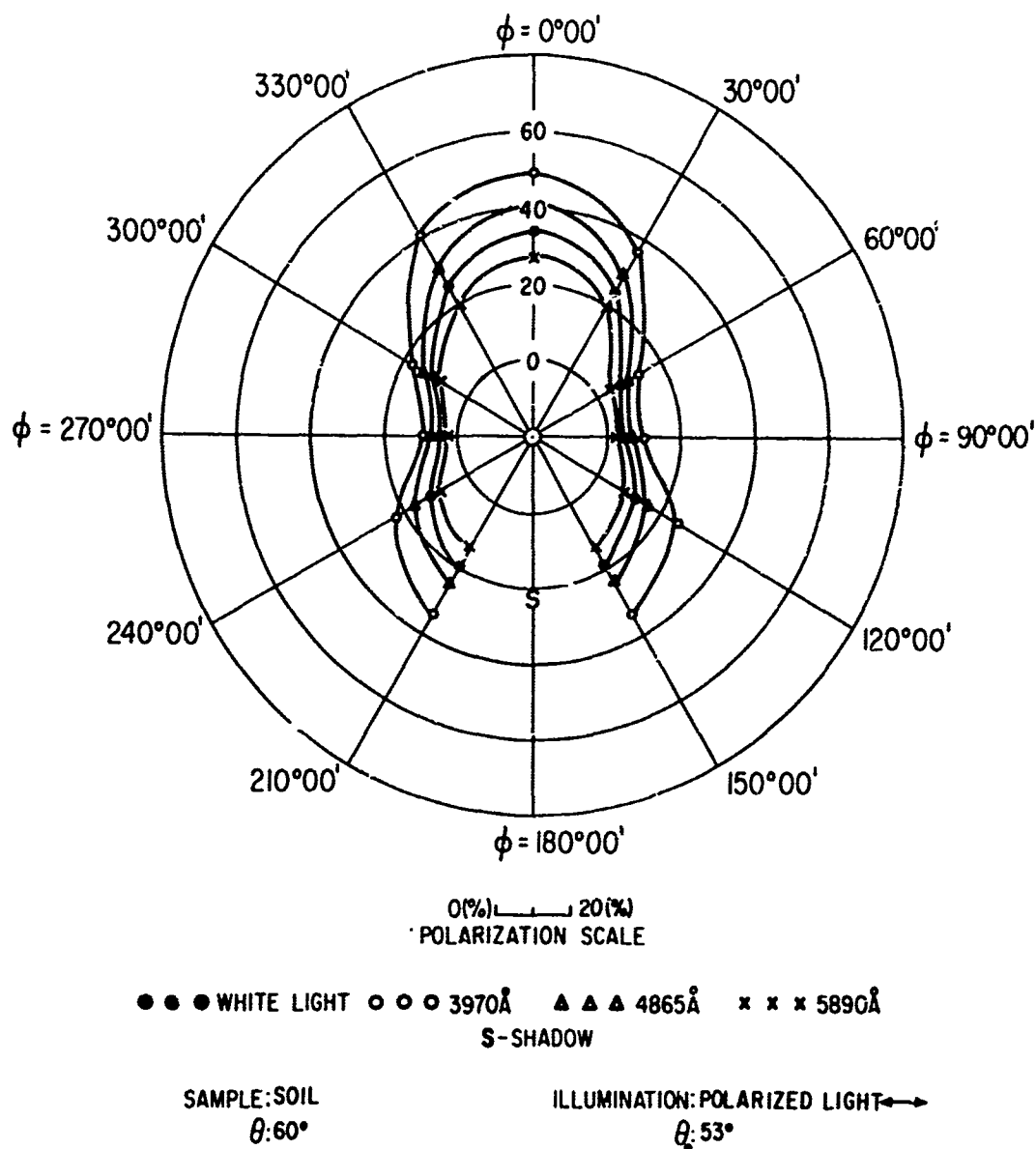
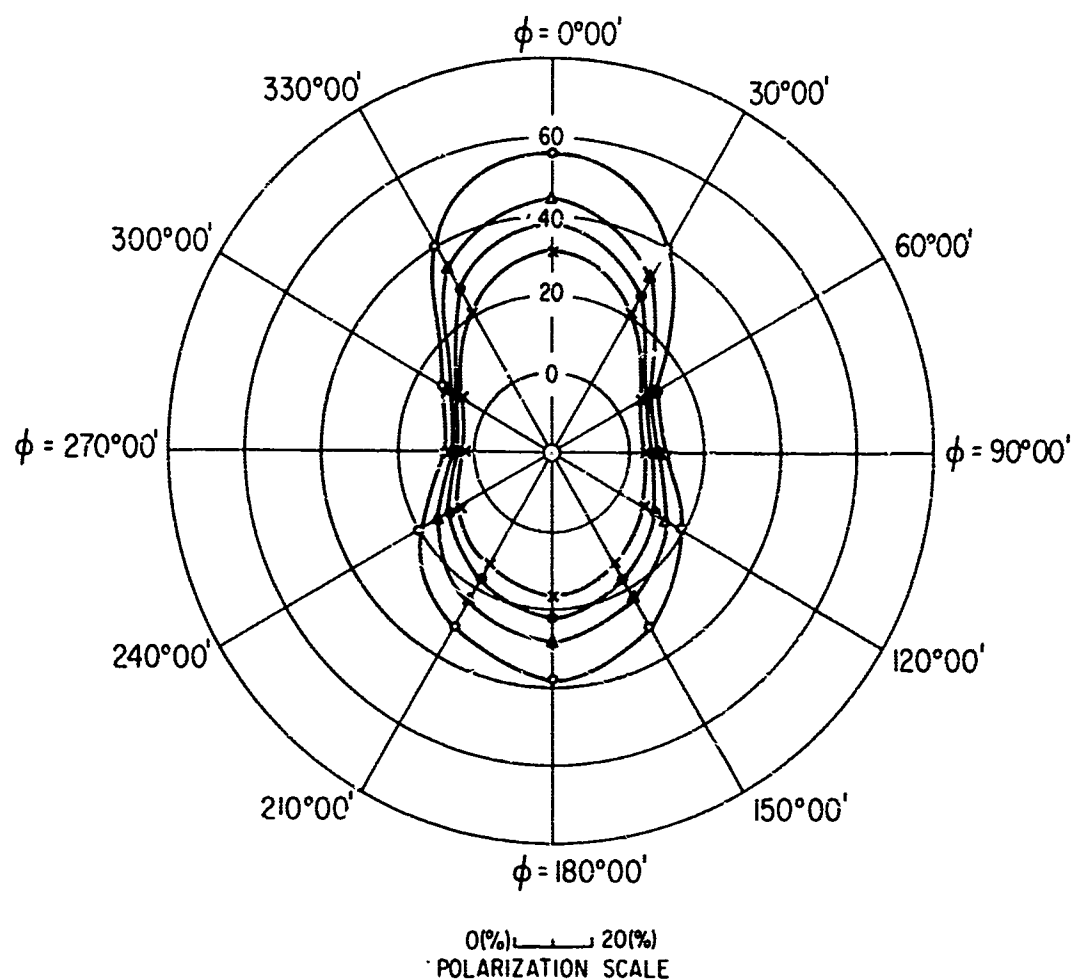


FIG.220 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 16.43 + 3.16 \cos \phi + 11.80 \cos 2\phi + 3.05 \cos 3\phi + 0.32 \cos 4\phi - 0.51 \cos 5\phi \\
 & + 0.30 \cos 6\phi - 0.80 \sin \phi + 0.61 \sin 2\phi - 0.48 \sin 3\phi + 0.23 \sin 4\phi + 0.21 \sin 5\phi
 \end{aligned}$$



● ● ● WHITE LIGHT ○ ○ ○ 3970 Å ▲ ▲ ▲ 4865 Å × × × 5890 Å
 S-SHADOW

SAMPLE: SOIL
 $\theta: 70^{\circ}$

ILLUMINATION: POLARIZED LIGHT \longleftrightarrow
 $\theta: 53^{\circ}$

FIG.221 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 16.49 + 4.87 \cos \varphi + 12.48 \cos 2\varphi + 3.62 \cos 3\varphi + 1.23 \cos 4\varphi - 0.59 \cos 5\varphi \\
 & - 0.02 \cos 6\varphi - 0.18 \sin \varphi - 0.40 \sin 2\varphi - 0.60 \sin 3\varphi + 0.09 \sin 4\varphi + 0.33 \sin 5\varphi
 \end{aligned}$$

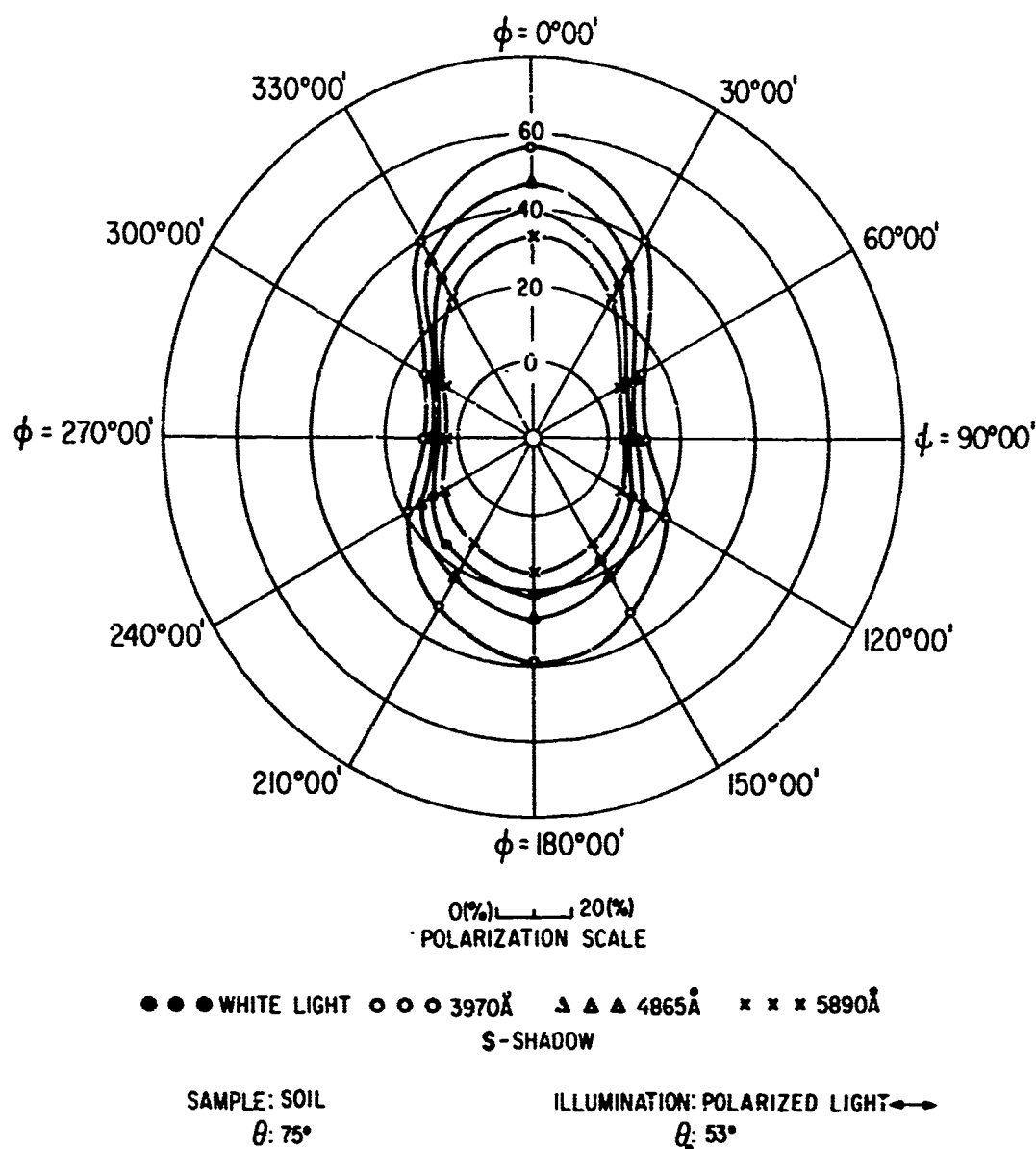


FIG.222 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 16.94 + 6.09 \cos \varphi + 12.61 \cos 2\varphi + 3.82 \cos 3\varphi + 1.61 \cos 4\varphi - 0.61 \cos 5\varphi \\
 & - 0.32 \cos 6\varphi - 0.29 \sin \varphi - 0.27 \sin 2\varphi - 0.40 \sin 3\varphi - 0.19 \sin 4\varphi + 0.09 \sin 5\varphi
 \end{aligned}$$

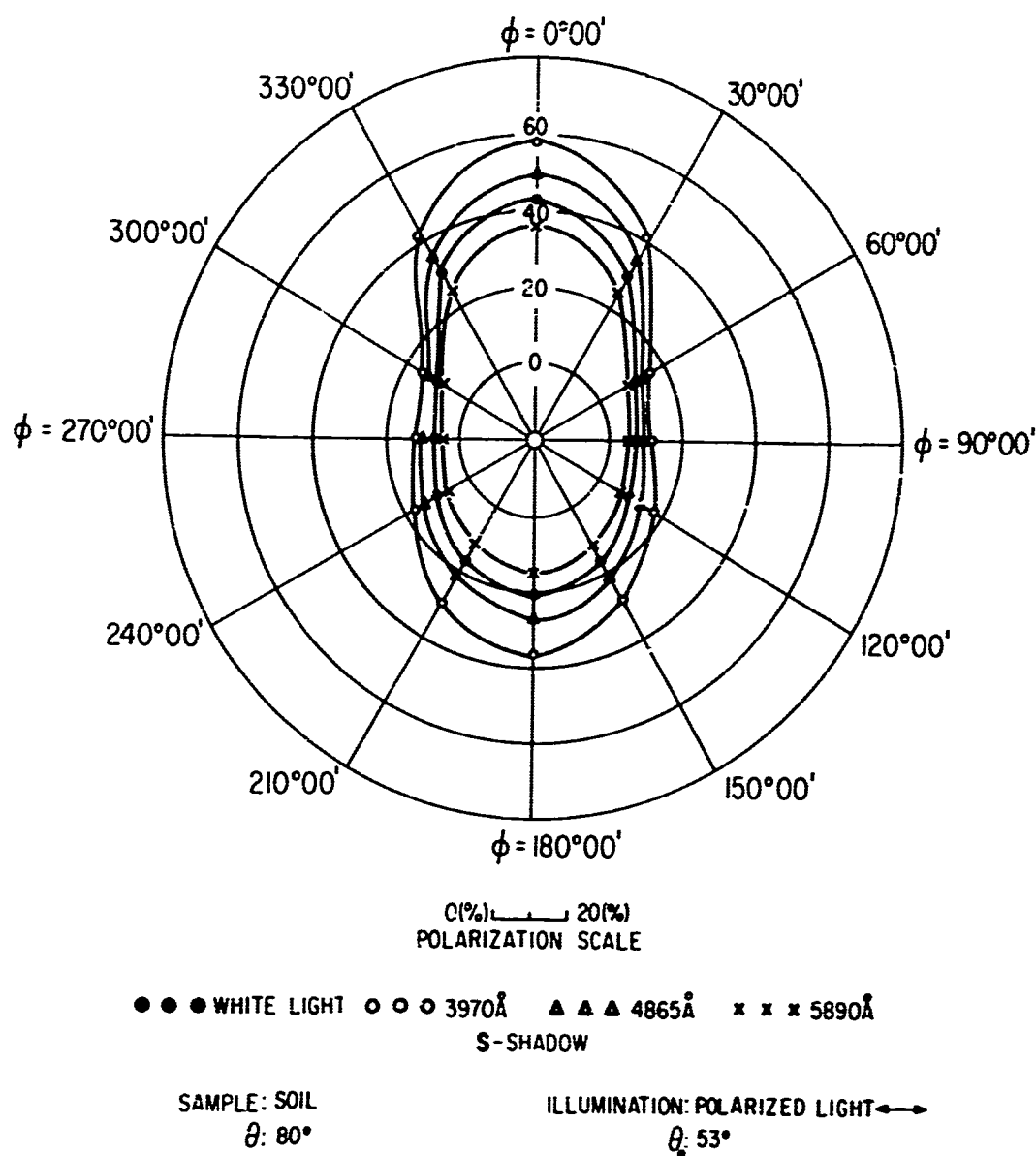


FIG.223 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 17.83 + 7.83 \cos \varphi + 12.93 \cos 2\varphi + 3.37 \cos 3\varphi + 1.92 \cos 4\varphi - 0.15 \cos 5\varphi \\
 & - 0.67 \cos 6\varphi - 0.06 \sin \varphi - 0.20 \sin 2\varphi - 0.33 \sin 3\varphi - 0.17 \sin 4\varphi + 0.08 \sin 5\varphi
 \end{aligned}$$

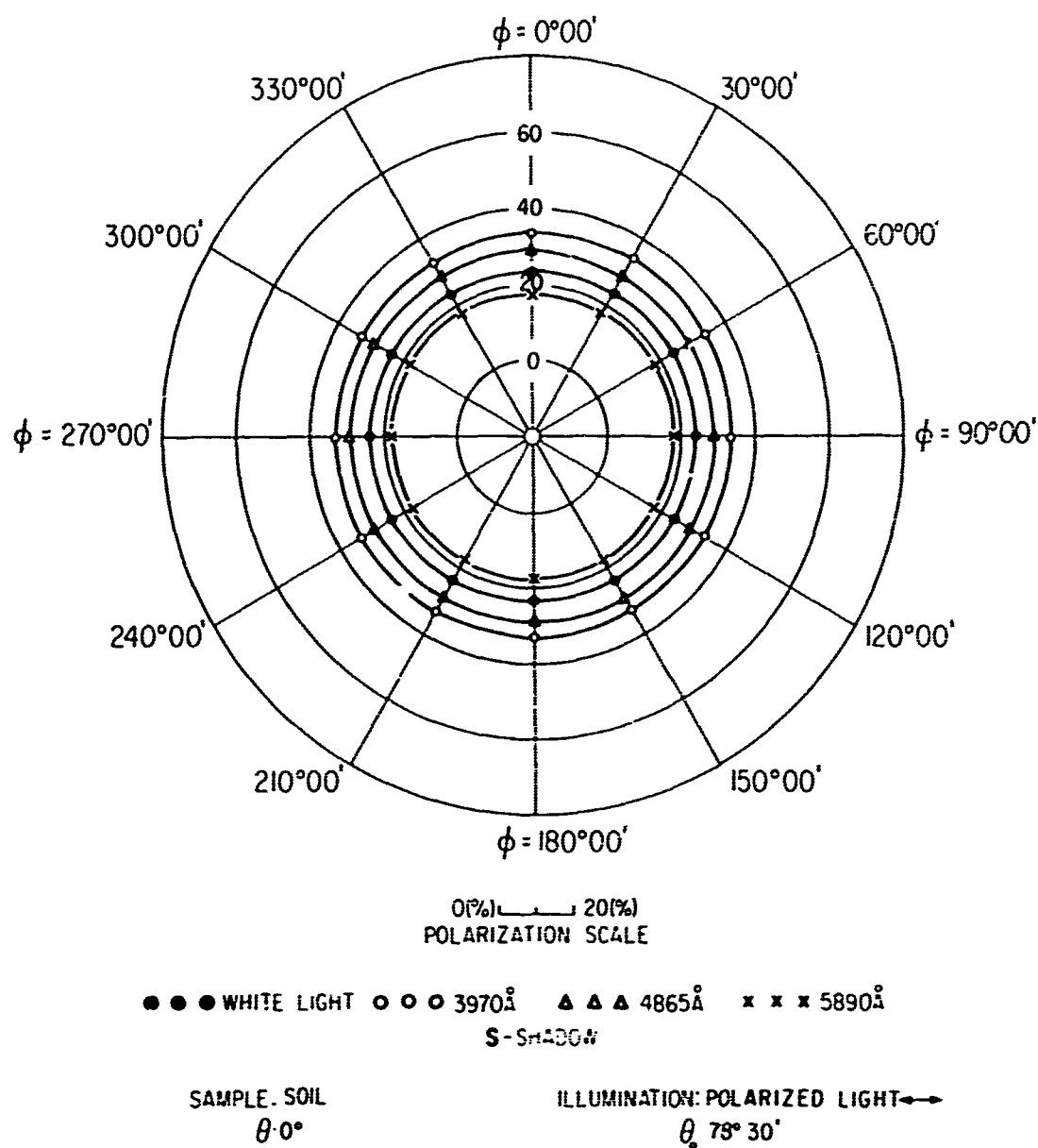


FIG 224 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

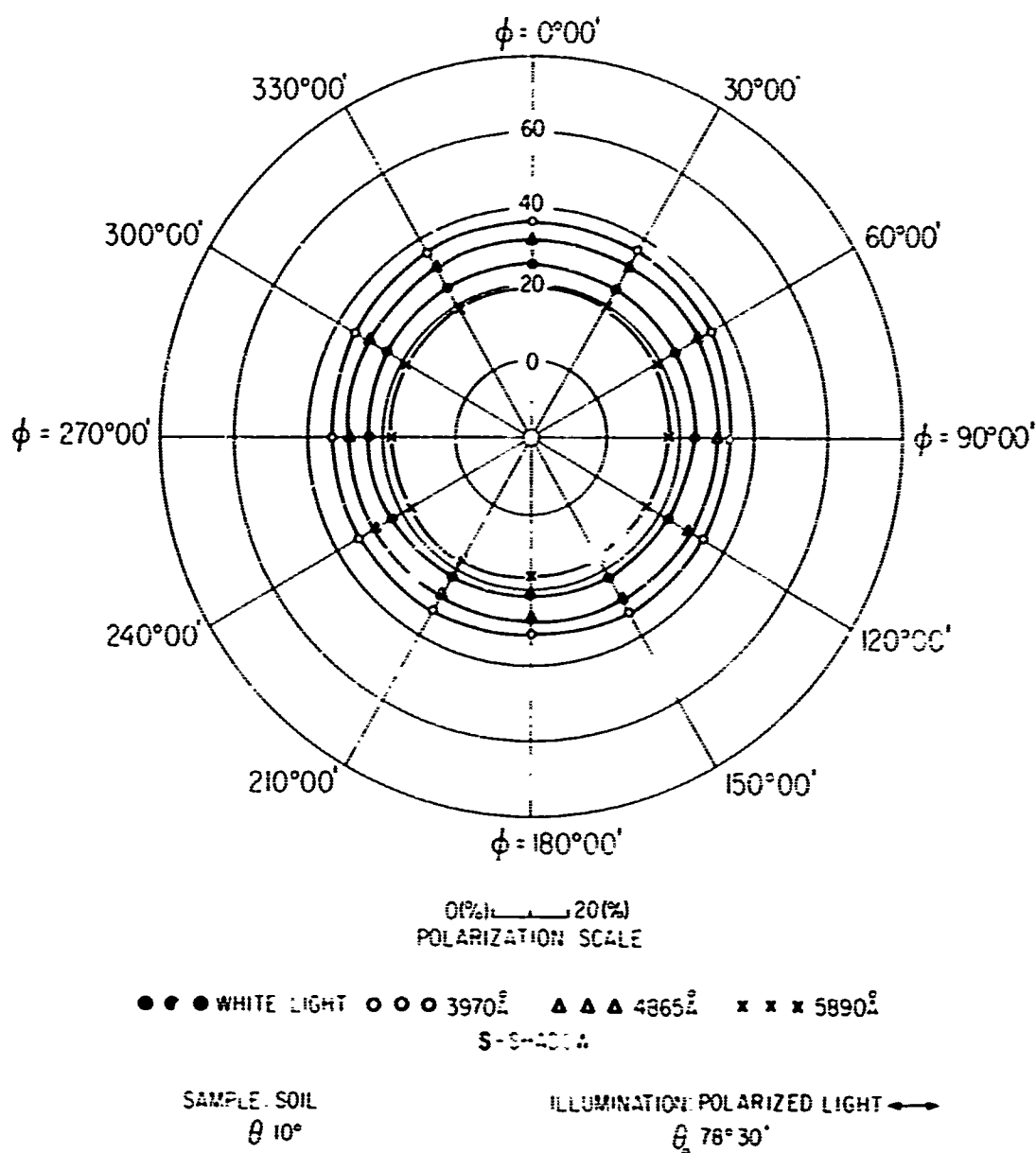


FIG 225 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 23.18 + 2.47 \cos \phi + 0.53 \cos 2\phi + 0.05 \cos 3\phi - 0.03 \cos 4\phi - 0.27 \cos 5\phi \\
 & - 0.07 \cos 6\phi - 0.73 \sin \phi + 0.39 \sin 2\phi + 0.05 \sin 3\phi + 0.79 \sin 4\phi - 0.27 \sin 5\phi
 \end{aligned}$$

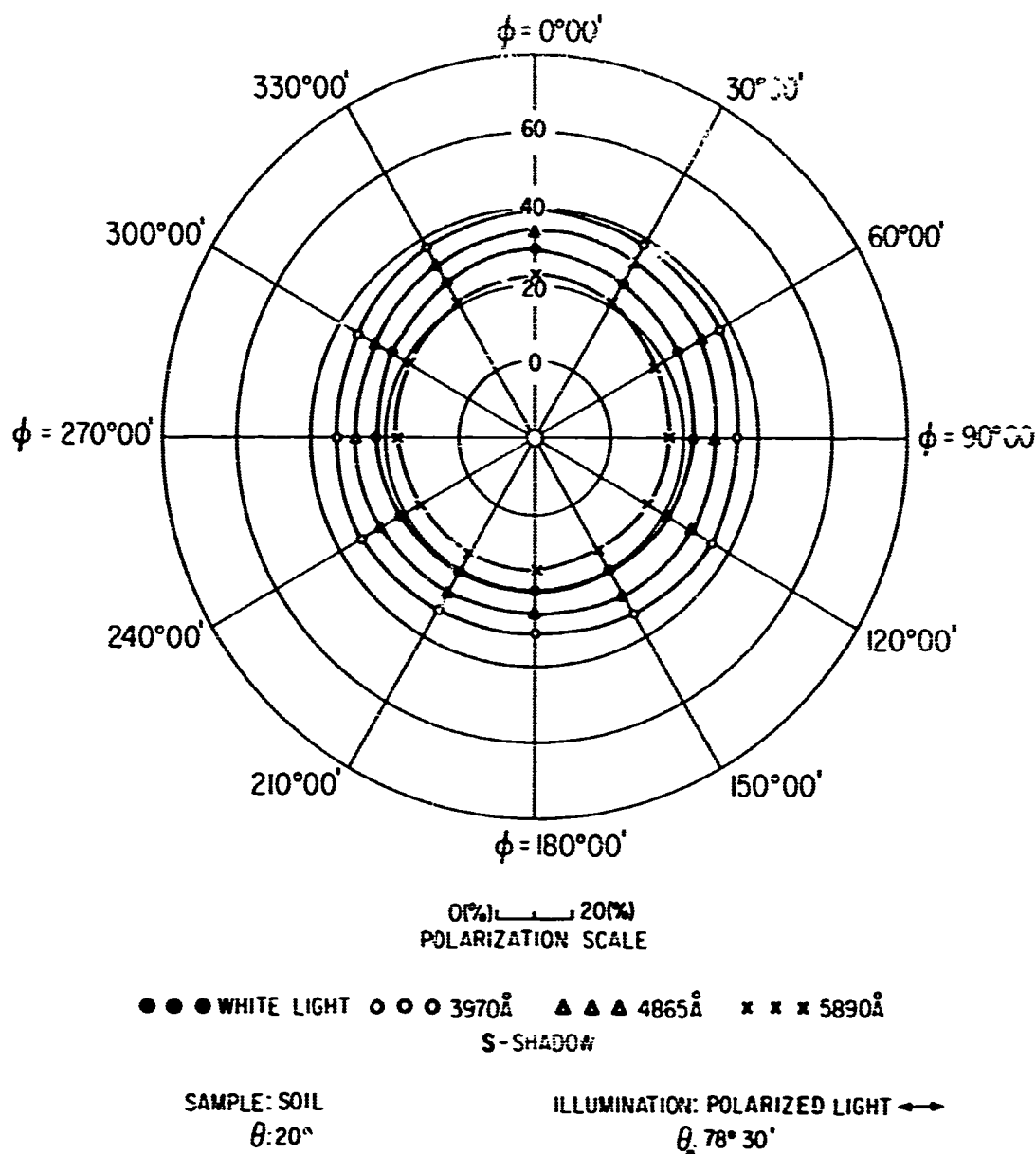


FIG226 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 23.98 + 3.91 \cos \varphi + 1.05 \cos 2\varphi + 0.57 \cos 3\varphi + 0.35 \cos 4\varphi - 0.08 \cos 5\varphi \\
 & + 0.30 \cos 6\varphi - 0.38 \sin \varphi - 0.15 \sin 2\varphi - 0.50 \sin 3\varphi + 0.49 \sin 4\varphi - 0.02 \sin 5\varphi
 \end{aligned}$$

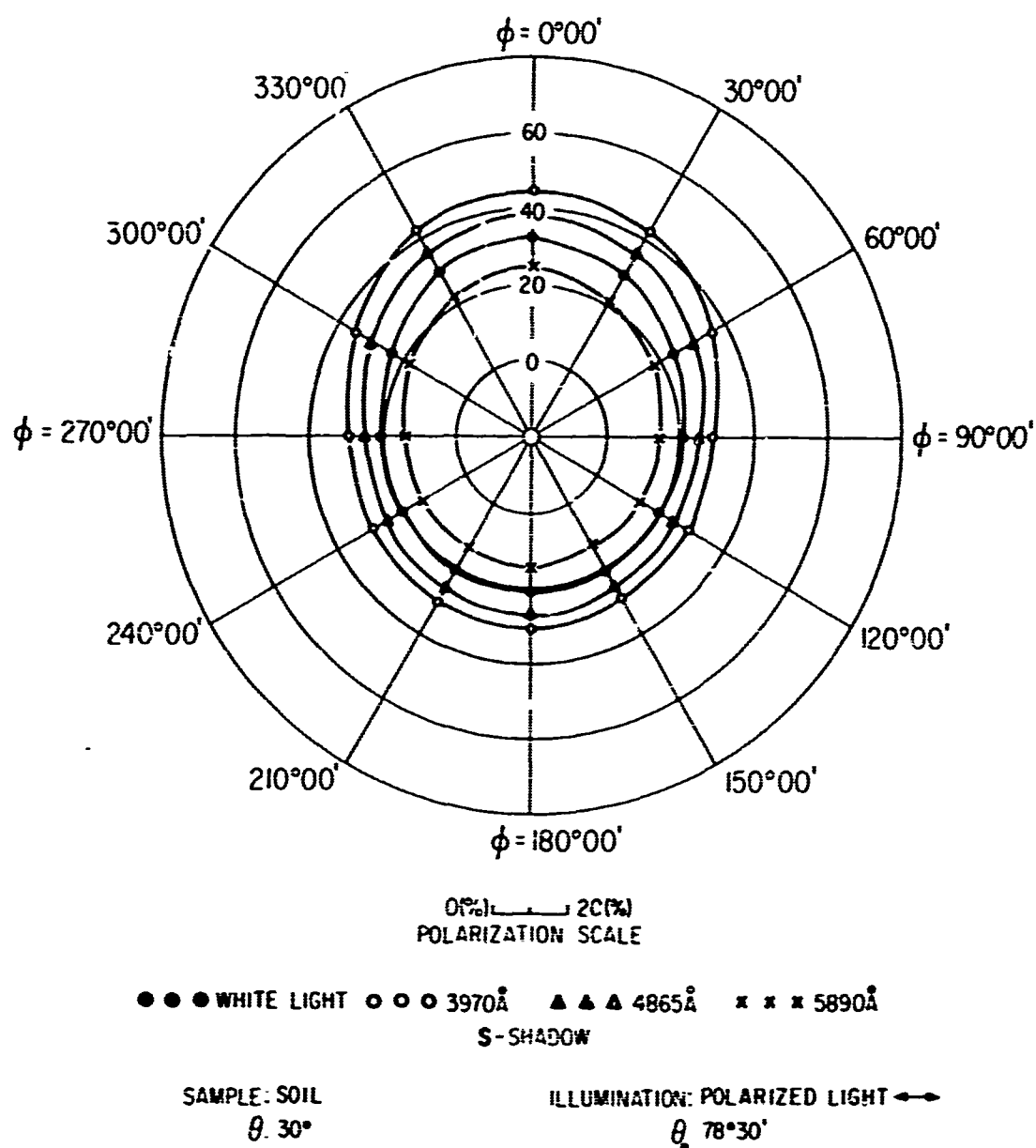


FIG.227 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 22.88 + 5.76 \cos \varphi + 2.78 \cos 2\varphi + 0.02 \cos 3\varphi + 0.54 \cos 4\varphi + 0.34 \cos 5\varphi \\
 & + 0.40 \cos 6\varphi + 0.06 \sin \varphi + 0.56 \sin 2\varphi - 0.95 \sin 3\varphi - 0.79 \sin 4\varphi - 0.76 \sin 5\varphi
 \end{aligned}$$

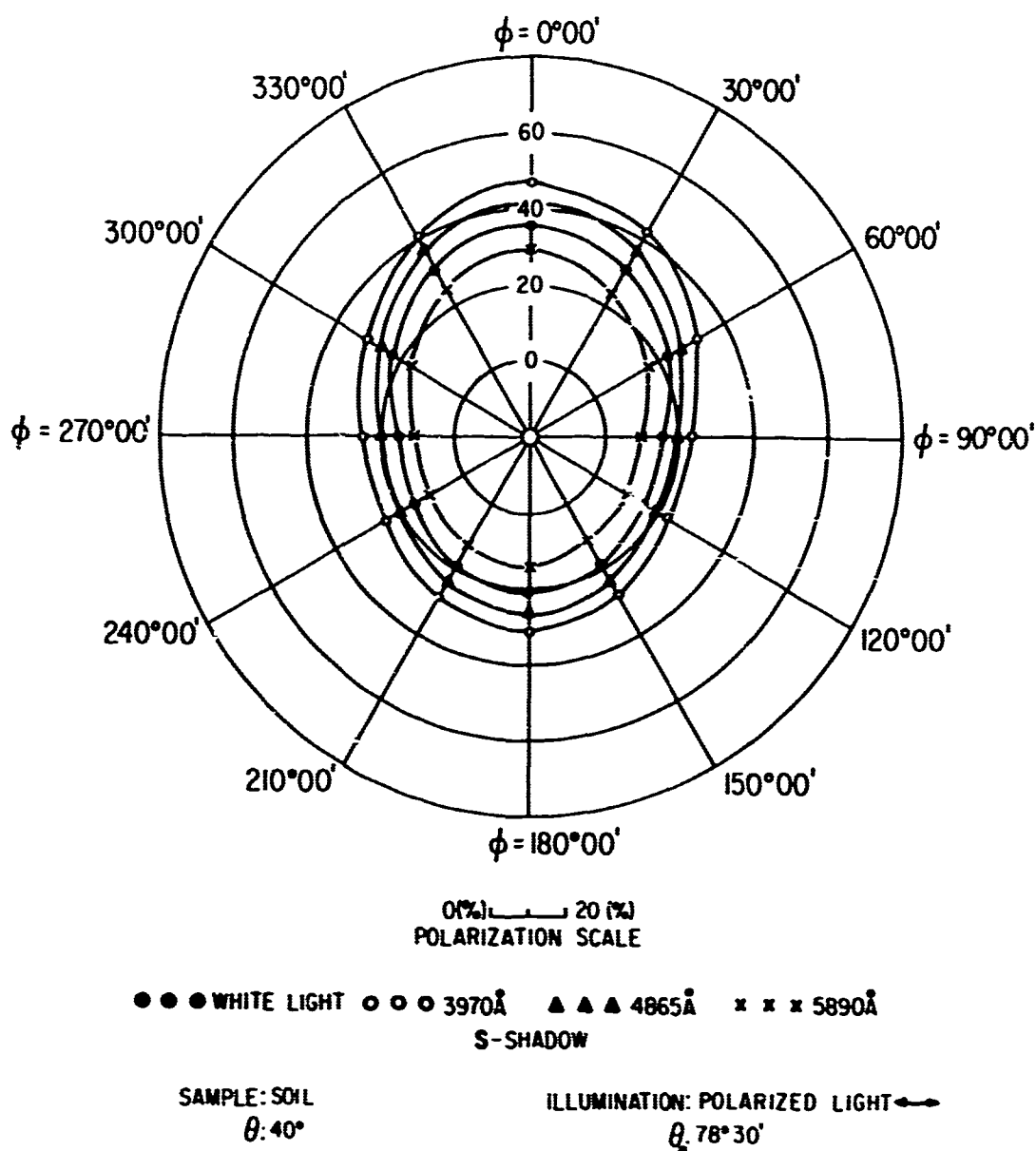


FIG.228 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 21.31 + 7.33 \cos \varphi + 6.00 \cos 2\varphi + 0.40 \cos 3\varphi + 0.22 \cos 4\varphi + 0.32 \cos 5\varphi \\
 & + 1.25 \cos 6\varphi - 0.46 \sin \varphi - 0.06 \sin 2\varphi - 0.82 \sin 3\varphi - 0.09 \sin 4\varphi - 0.36 \sin 5\varphi
 \end{aligned}$$

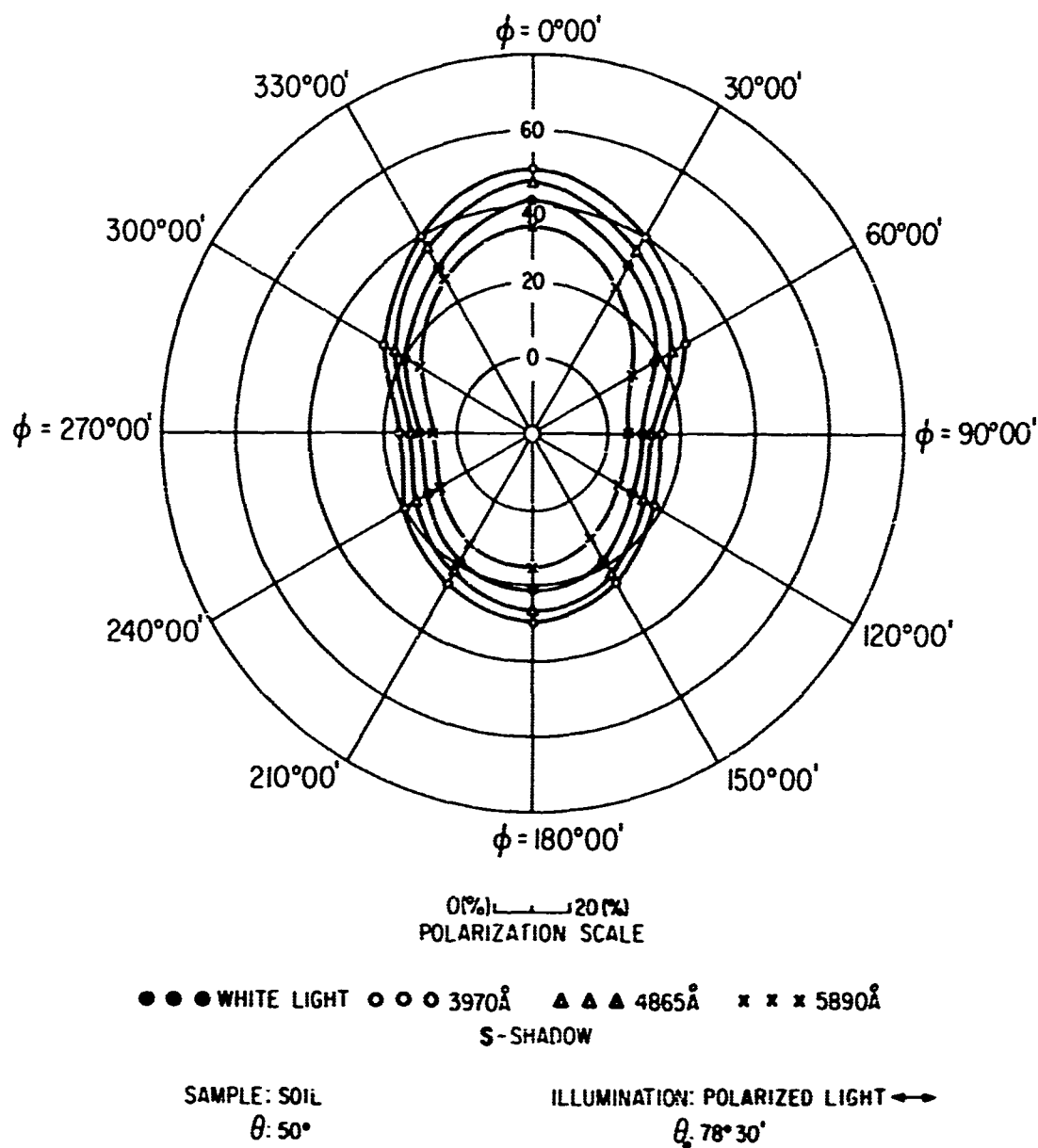


FIG.229 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 20.44 + 8.89 \cos \varphi + 10.59 \cos 2\varphi + 0.20 \cos 3\varphi + 0.01 \cos 4\varphi + 1.11 \cos 5\varphi \\
 & + 1.12 \cos 6\varphi - 1.29 \sin \varphi + 0.10 \sin 2\varphi - 0.98 \sin 3\varphi - 0.13 \sin 4\varphi + 0.31 \sin 5\varphi
 \end{aligned}$$

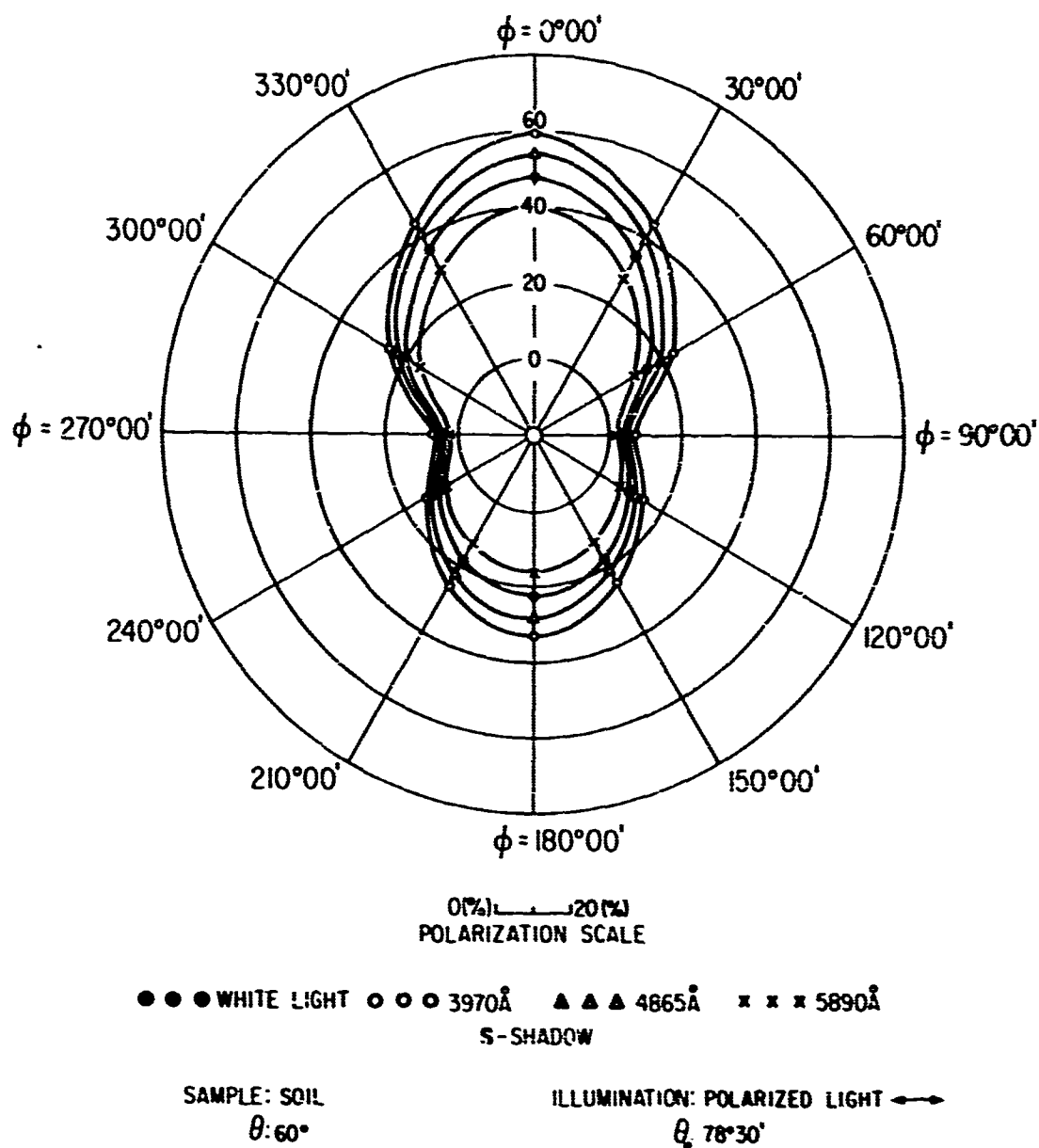


FIG. 230 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 19.24 + 10.79 \cos \varphi + 15.30 \cos 2\varphi + 0.70 \cos 3\varphi - 0.68 \cos 4\varphi + 1.16 \cos 5\varphi \\
 & + 2.85 \cos 6\varphi - 0.25 \sin \varphi - 0.29 \sin 2\varphi - 0.28 \sin 3\varphi - 0.26 \sin 4\varphi - 0.63 \sin 5\varphi
 \end{aligned}$$

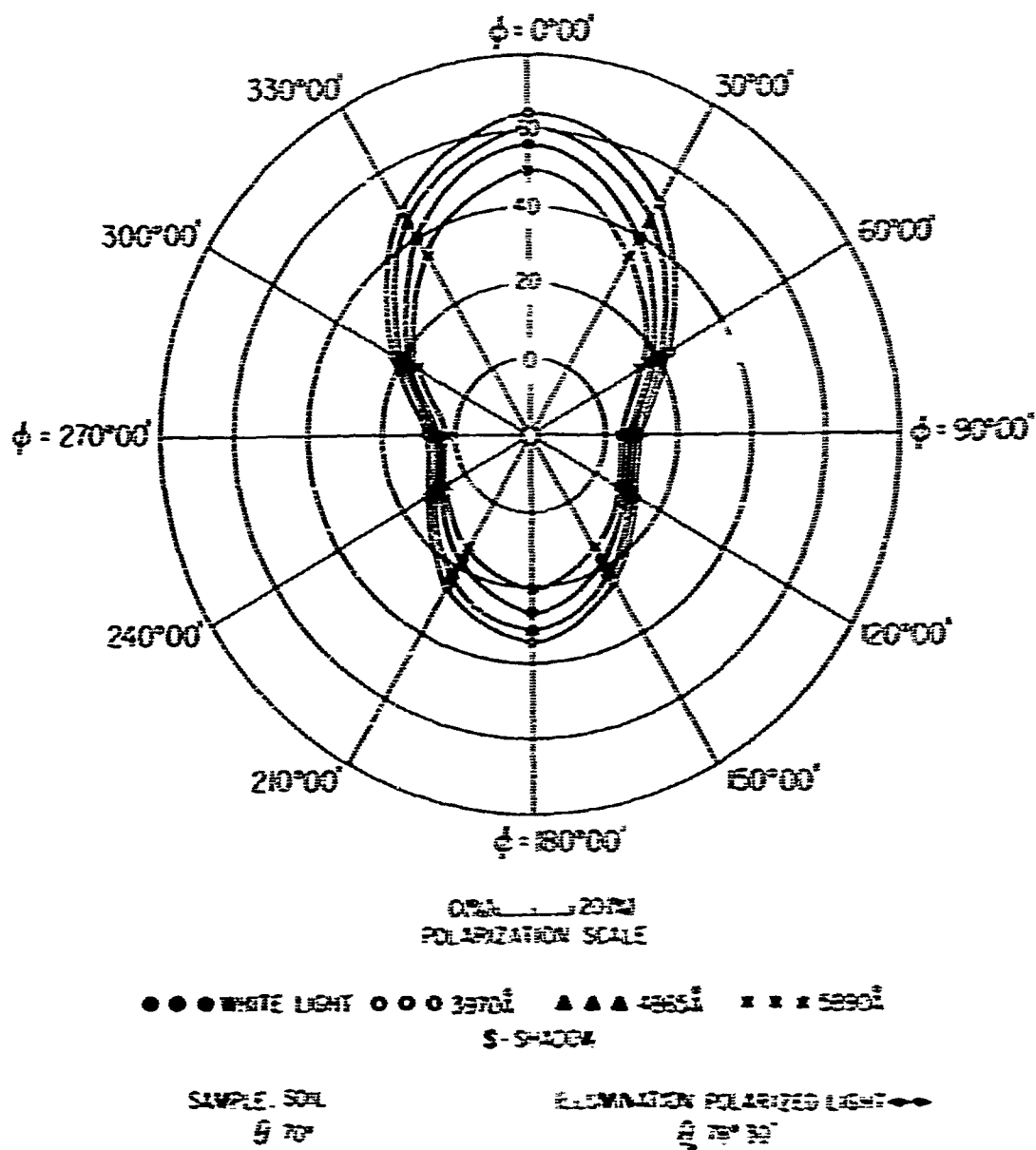


FIG 231 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 21.28 + 12.48 \cos \phi + 17.64 \cos 2\phi + 1.90 \cos 3\phi + 2.11 \cos 4\phi + 0.27 \cos 5\phi \\ + 1.25 \cos 6\phi + 0.10 \sin \phi - 0.58 \sin 2\phi - 0.22 \sin 3\phi + 0.37 \sin 4\phi - 0.07 \sin 5\phi$$

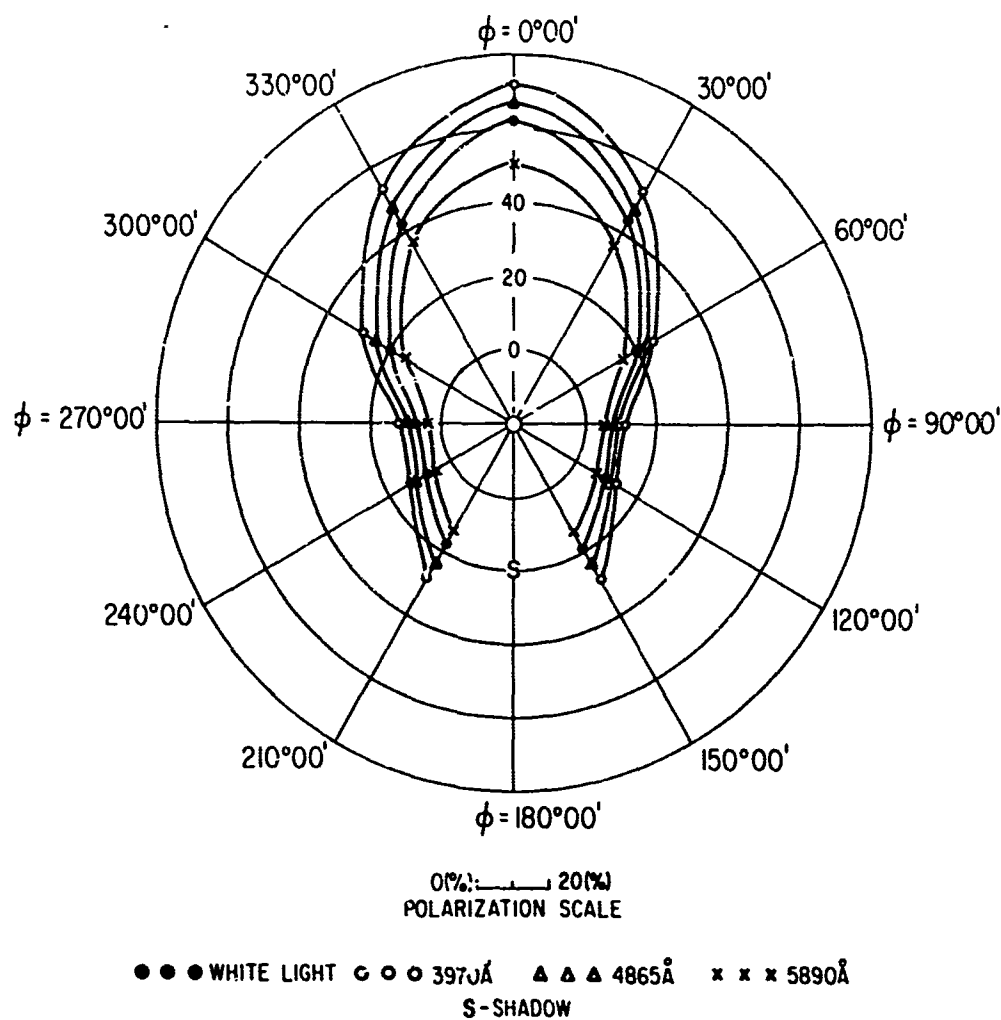


FIG.232 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 23.44 + 14.99 \cos \varphi + 18.82 \cos 2\varphi + 3.33 \cos 3\varphi + 3.53 \cos 4\varphi + 0.93 \cos 5\varphi \\
 & + 0.92 \cos 6\varphi + 96 \sin \varphi - 0.03 \sin 2\varphi + 0.28 \sin 3\varphi + 0.06 \sin 4\varphi + 0.20 \sin 5\varphi
 \end{aligned}$$

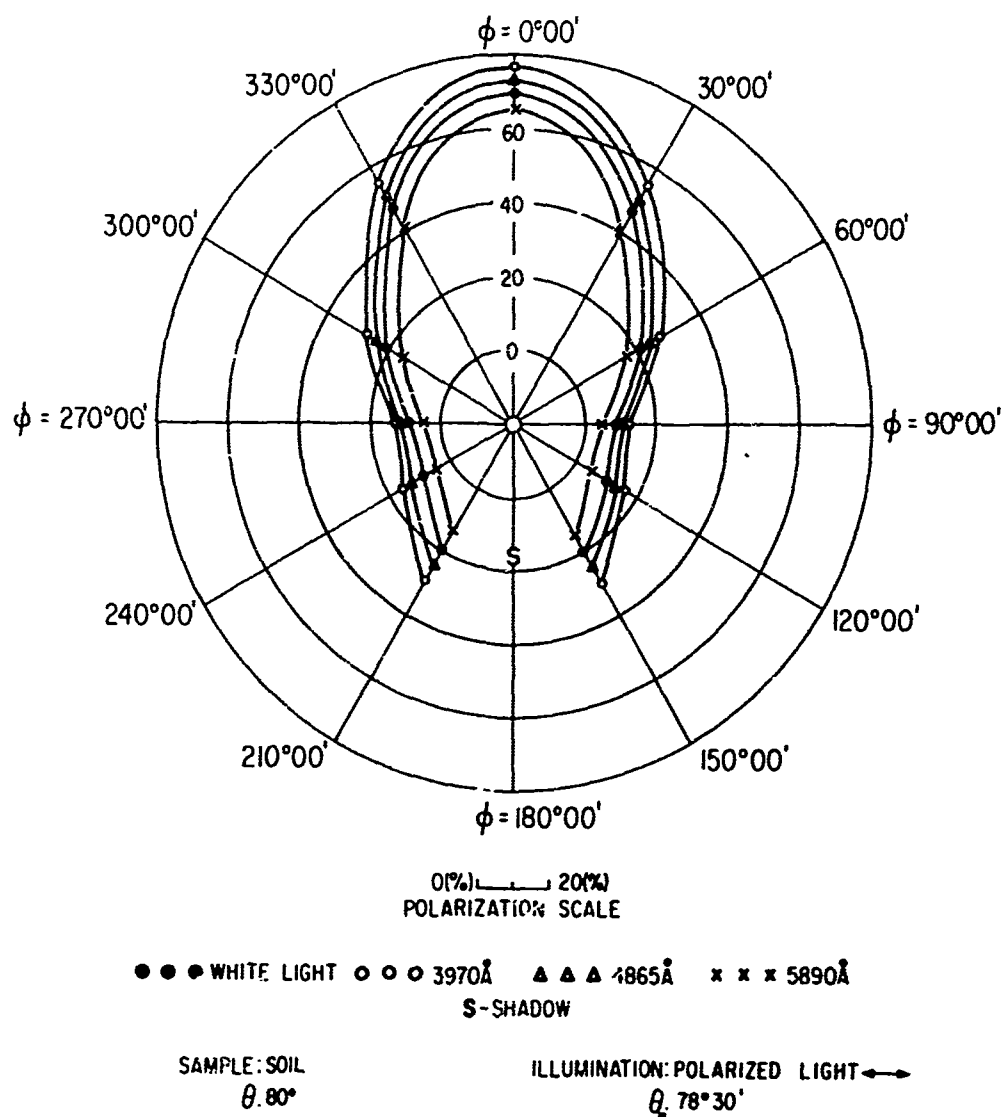


FIG.233 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 26.24 + 16.34 \cos \varphi + 19.53 \cos 2\varphi + 3.47 \cos 3\varphi + 2.27 \cos 4\varphi + 1.10 \cos 5\varphi \\
 & + 1.38 \cos 6\varphi + 0.59 \sin \varphi - 0.90 \sin 2\varphi - 0.75 \sin 3\varphi - 0.02 \sin 4\varphi + 0.01 \sin 5\varphi
 \end{aligned}$$

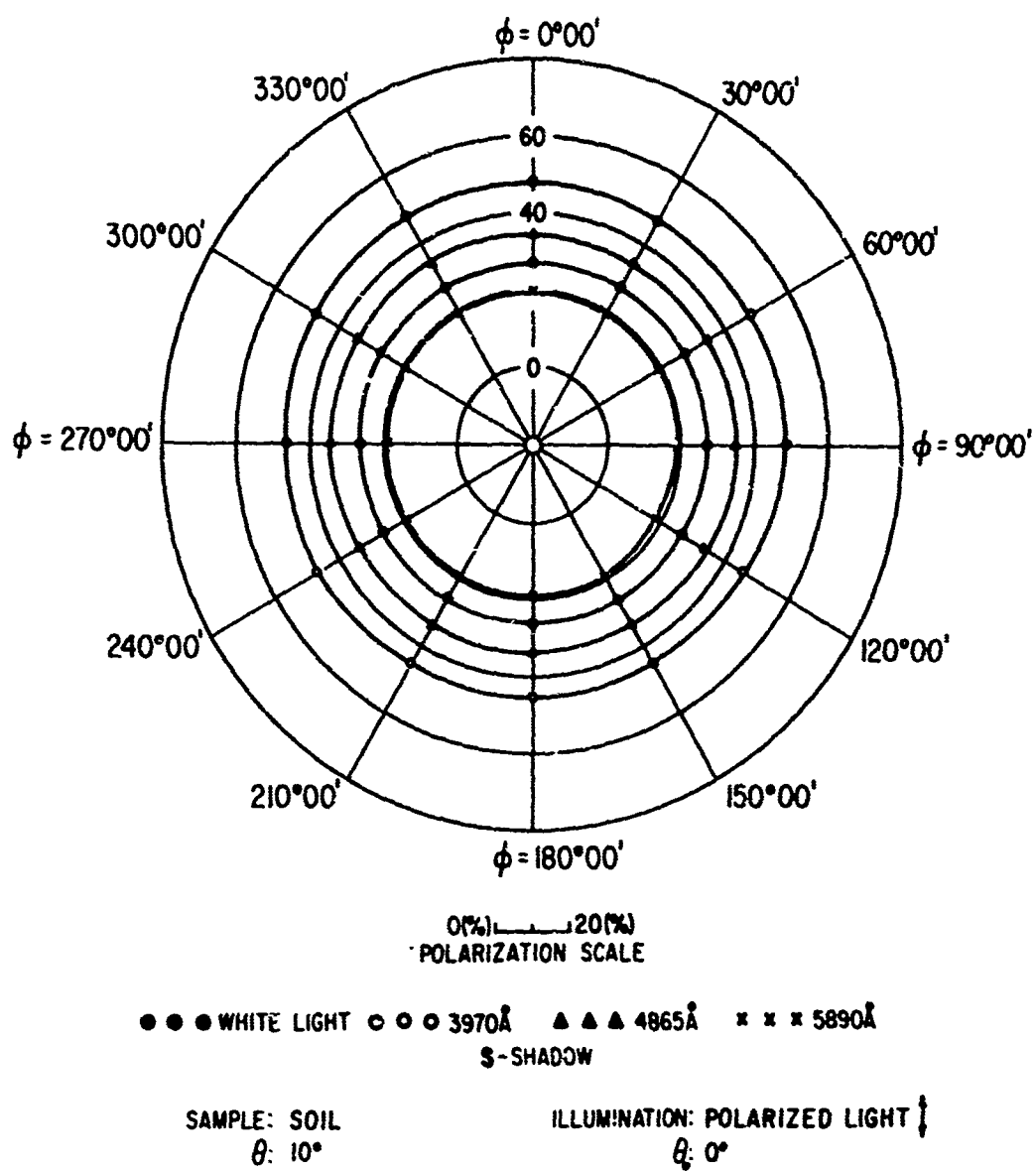


FIG. 234. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 26.45 + 0.02 \cos \varphi + 0.14 \cos 2\varphi - 0.07 \cos 3\varphi + 0.12 \cos 4\varphi - 0.03 \cos 5\varphi - 0.03 \cos 6\varphi + 0.14 \sin \varphi + 0.33 \sin 2\varphi + 0.07 \sin 3\varphi - 0.04 \sin 4\varphi - 0.07 \sin 5\varphi$$

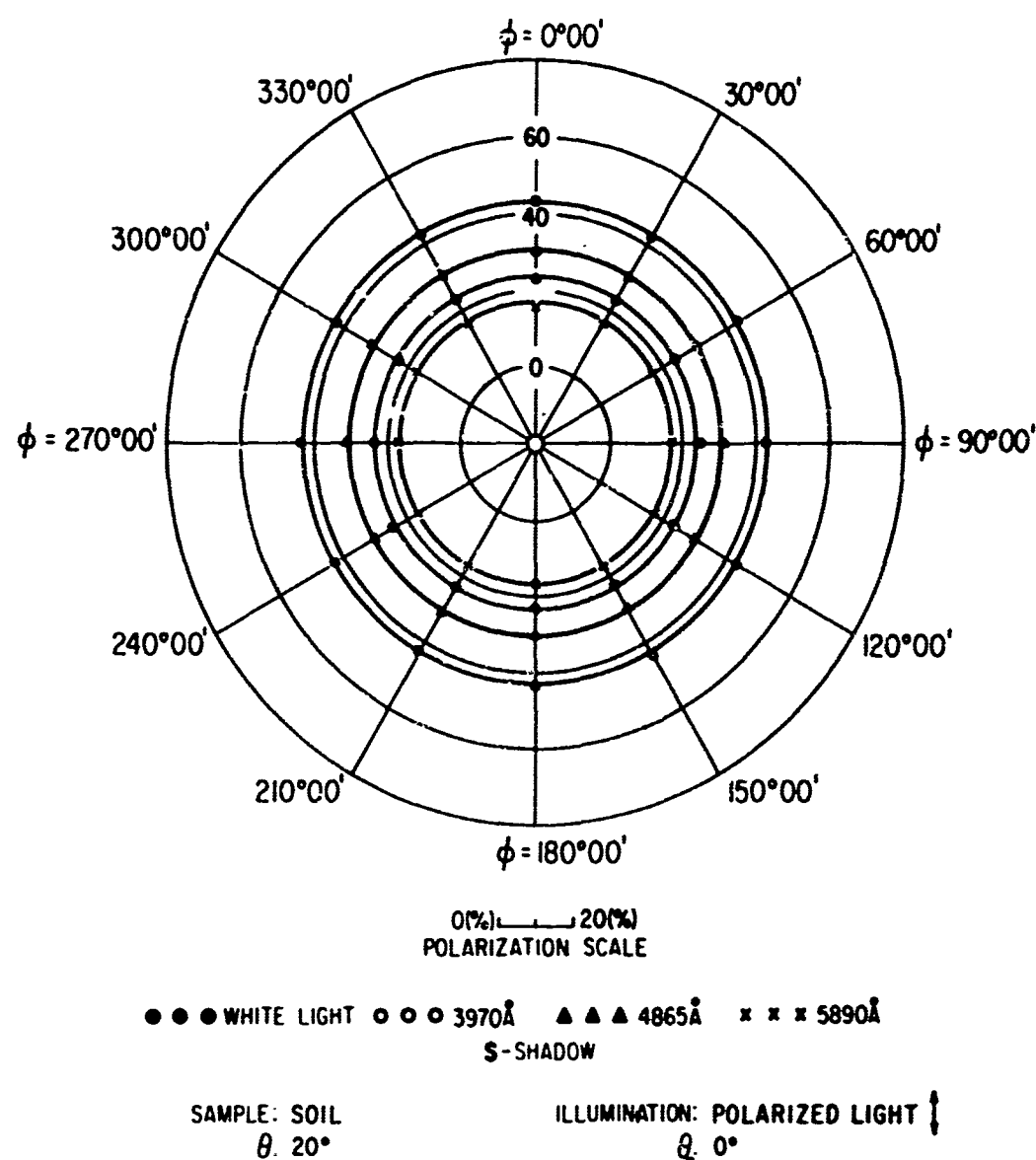


FIG. 235. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 23.18 + 0.05 \cos \phi - 0.76 \cos 2\phi + 0.18 \cos 3\phi + 0.59 \cos 4\phi - 0.02 \cos 5\phi \\
 & - 0.13 \cos 6\phi - 0.14 \sin \phi + 0.13 \sin 2\phi + 0.15 \sin 3\phi + 0.05 \sin 4\phi - 0.02 \sin 5\phi
 \end{aligned}$$

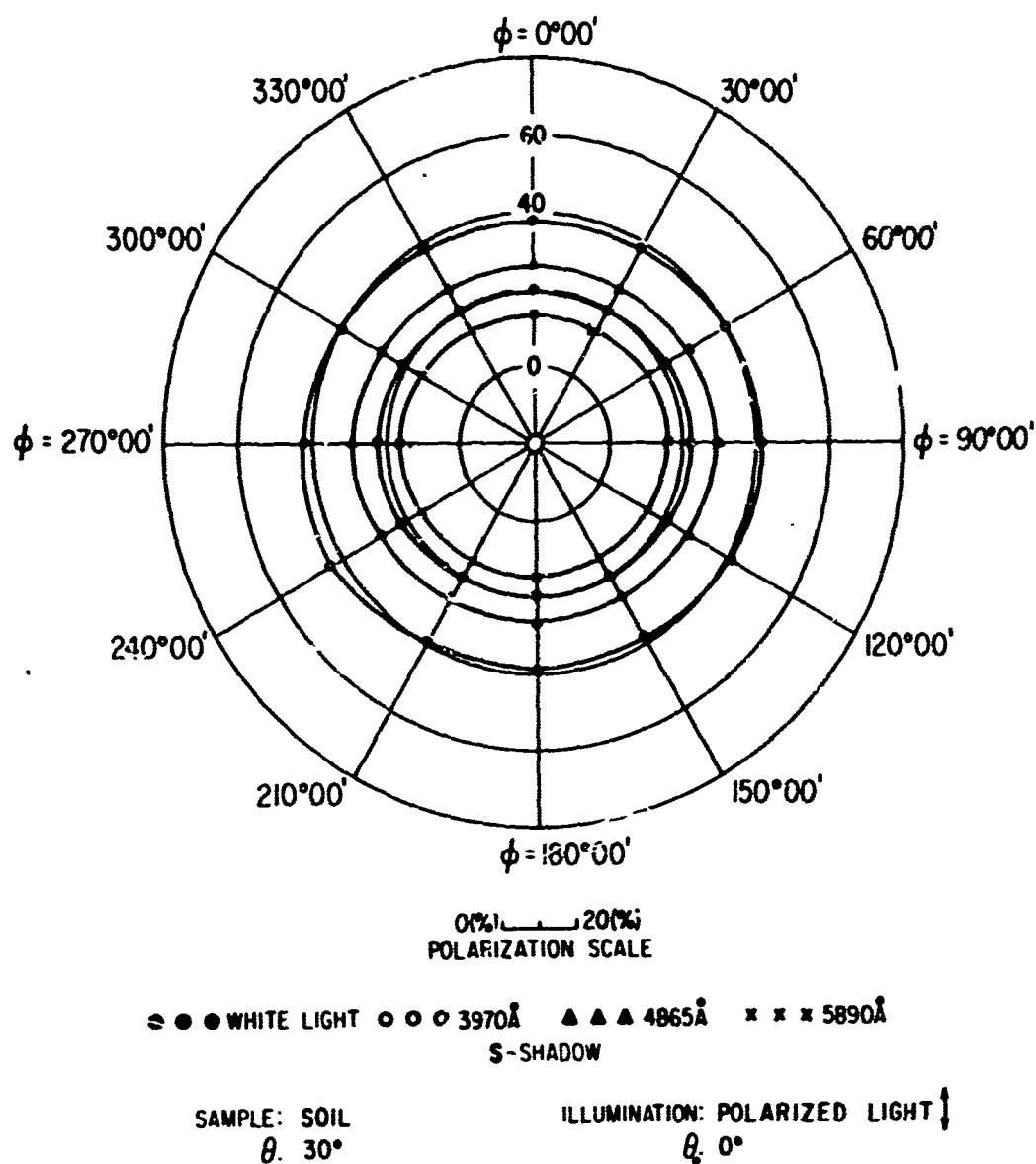


FIG. 236. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 20.62 - 0.08 \cos \phi - 1.53 \cos 2\phi + 0.05 \cos 3\phi + 0.31 \cos 4\phi + 0.11 \cos 5\phi \\
 & + 0.00 \cos 6\phi - 0.10 \sin \phi + 0.39 \sin 2\phi - 0.05 \sin 3\phi - 0.27 \sin 4\phi + 0.10 \sin 5\phi
 \end{aligned}$$

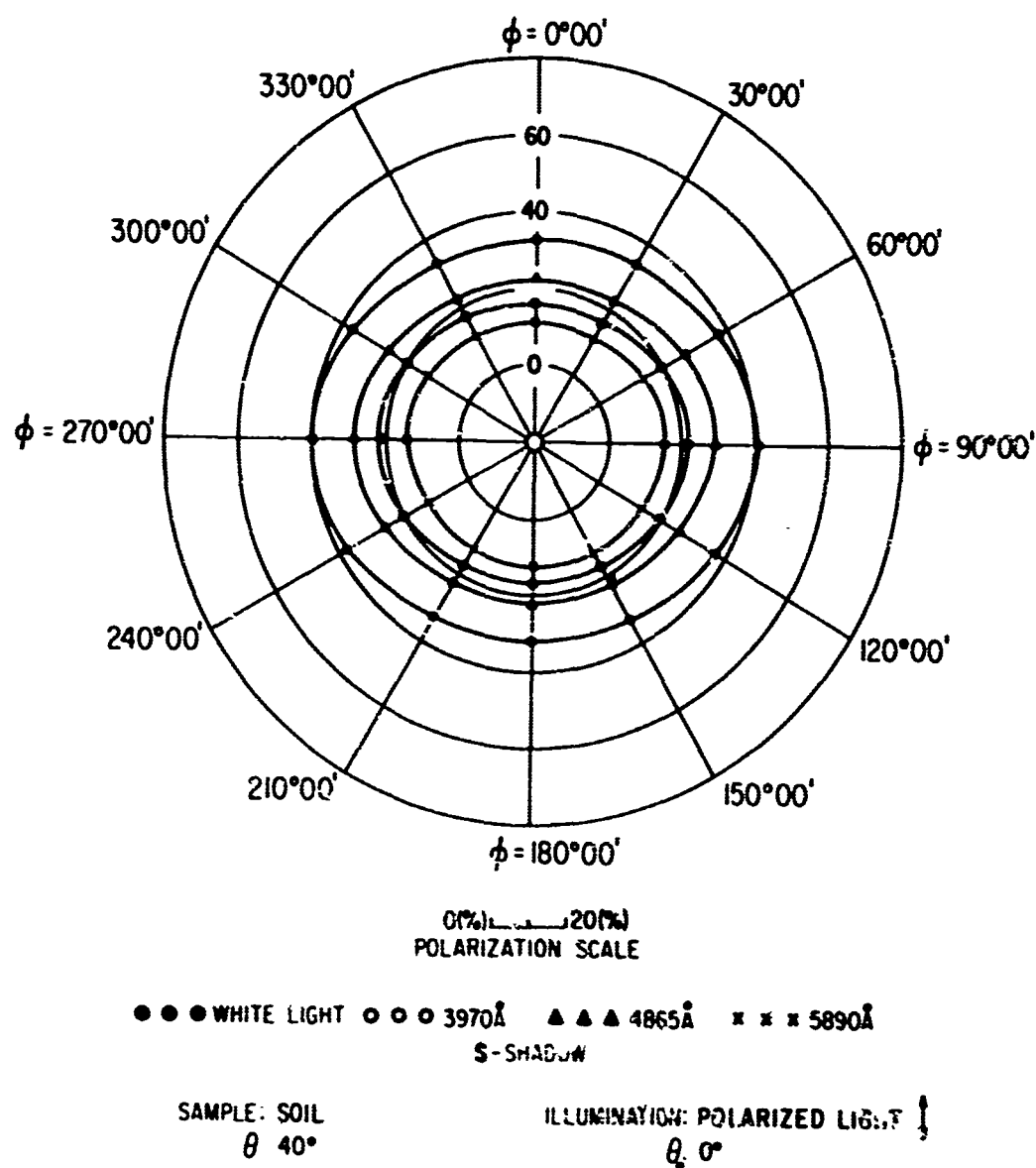


FIG. 237. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 18.48 - 0.15 \cos \phi - 2.57 \cos 2\phi + 0.18 \cos 3\phi + 0.37 \cos 4\phi - 0.08 \cos 5\phi \\
 & + 0.33 \cos 6\phi - 0.05 \sin \phi + 0.58 \sin 2\phi - 0.02 \sin 3\phi + 0.17 \sin 4\phi + 0.18 \sin 5\phi
 \end{aligned}$$

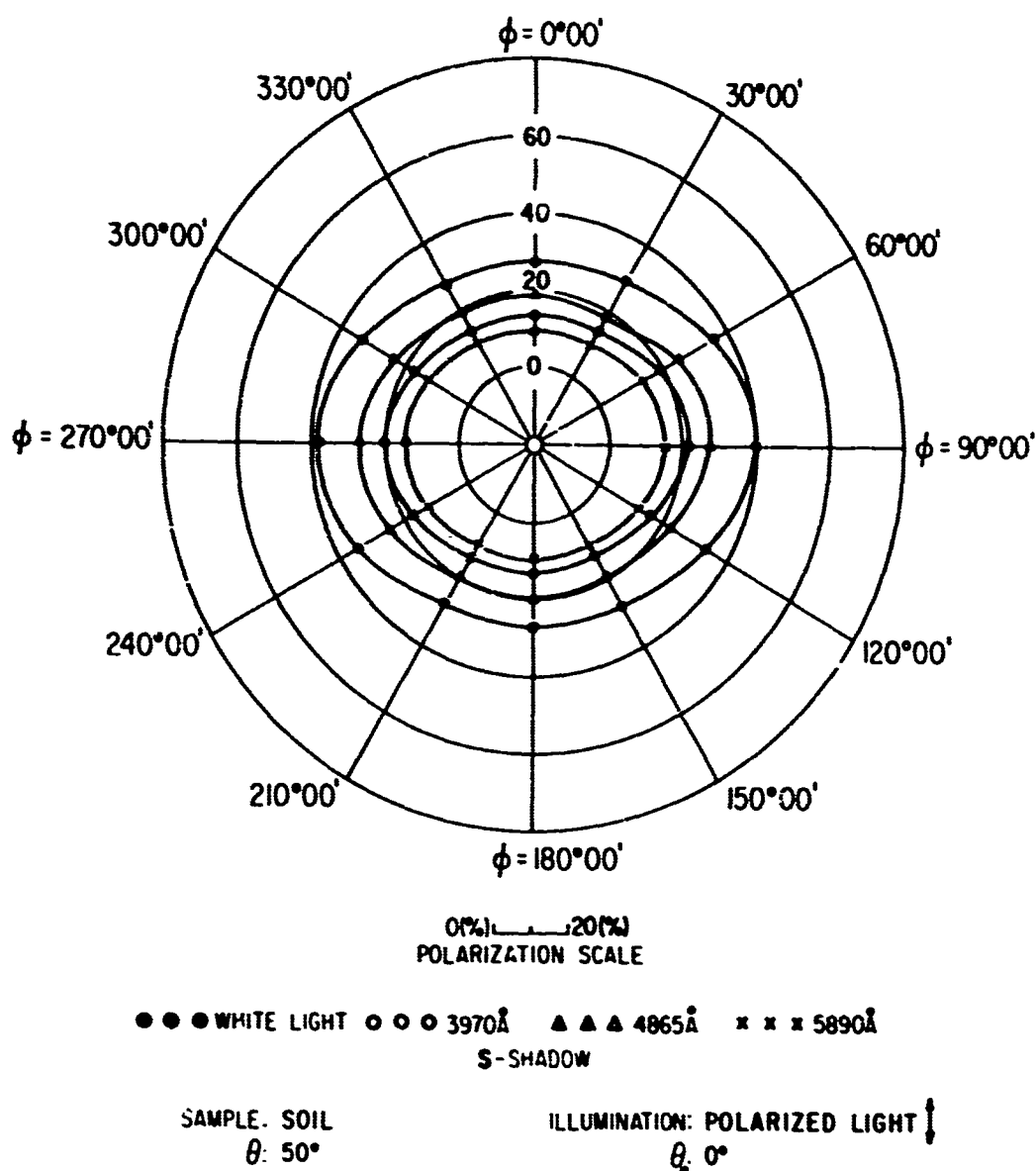


FIG. 238. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 15.65 + 0.60 \cos \varphi - 3.27 \cos 2\varphi - 1.42 \cos 3\varphi + 1.60 \cos 4\varphi + 0.66 \cos 5\varphi \\
 & - 1.07 \cos 6\varphi + 1.09 \sin \varphi - 0.61 \sin 2\varphi - 0.08 \sin 3\varphi + 0.89 \sin 4\varphi - 0.92 \sin 5\varphi
 \end{aligned}$$

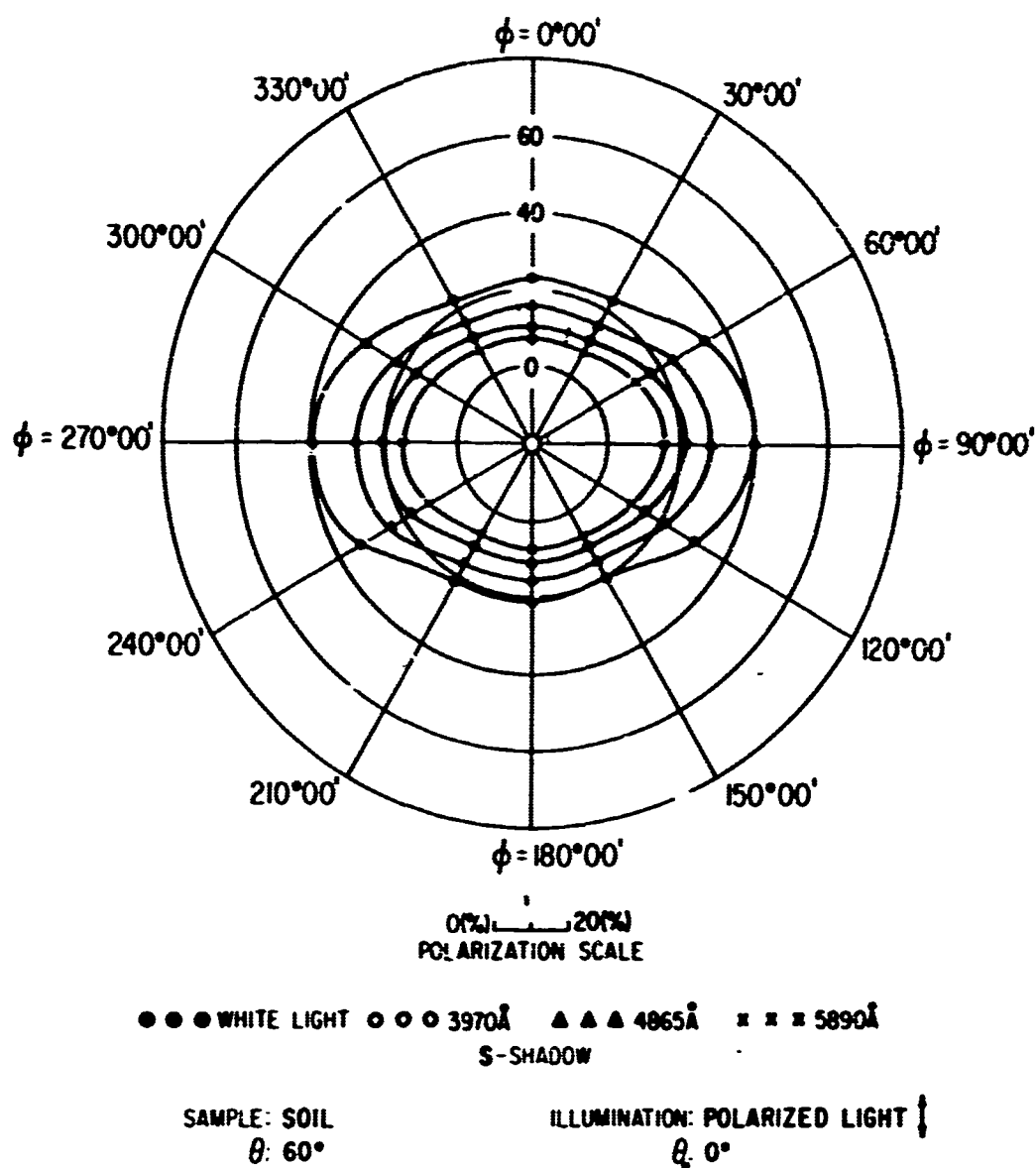


FIG. 239. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 13.95 + 0.06 \cos \phi - 4.07 \cos 2\phi - 0.13 \cos 3\phi + 0.65 \cos 4\phi - 0.08 \cos 5\phi \\
 & + 1.43 \cos 6\phi + 1.06 \sin \phi + 0.66 \sin 2\phi - 1.11 \sin 3\phi - 0.58 \sin 4\phi + 0.92 \sin 5\phi
 \end{aligned}$$

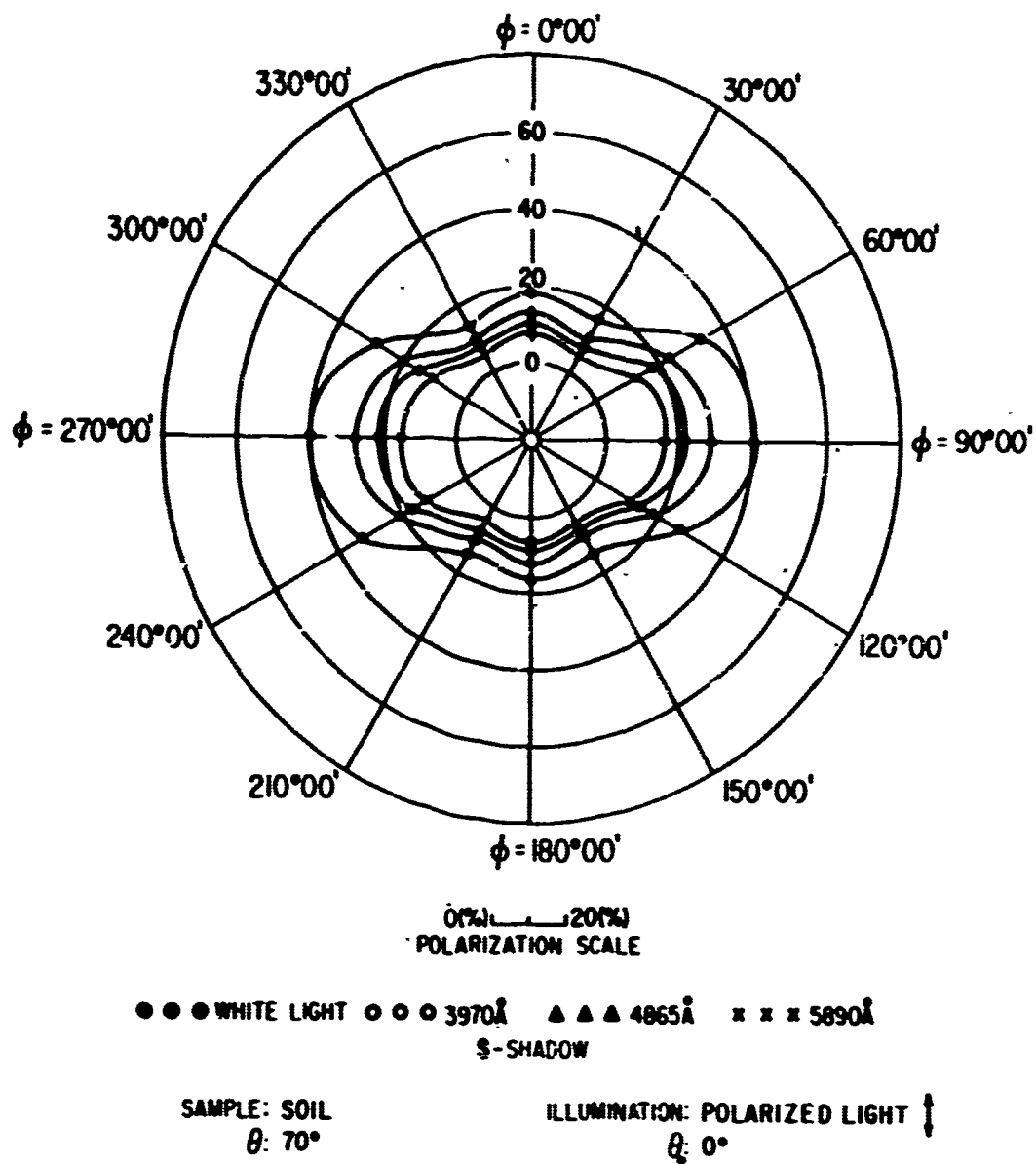


FIG. 240. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 13.07 - 0.15 \cos \varphi - 6.72 \cos 2\varphi + 0.08 \cos 3\varphi + 2.61 \cos 4\varphi + 0.14 \cos 5\varphi \\
 & + 1.52 \cos 6\varphi - 0.08 \sin \varphi + 1.08 \sin 2\varphi - 0.22 \sin 3\varphi - 0.56 \sin 4\varphi + 0.01 \sin 5\varphi
 \end{aligned}$$

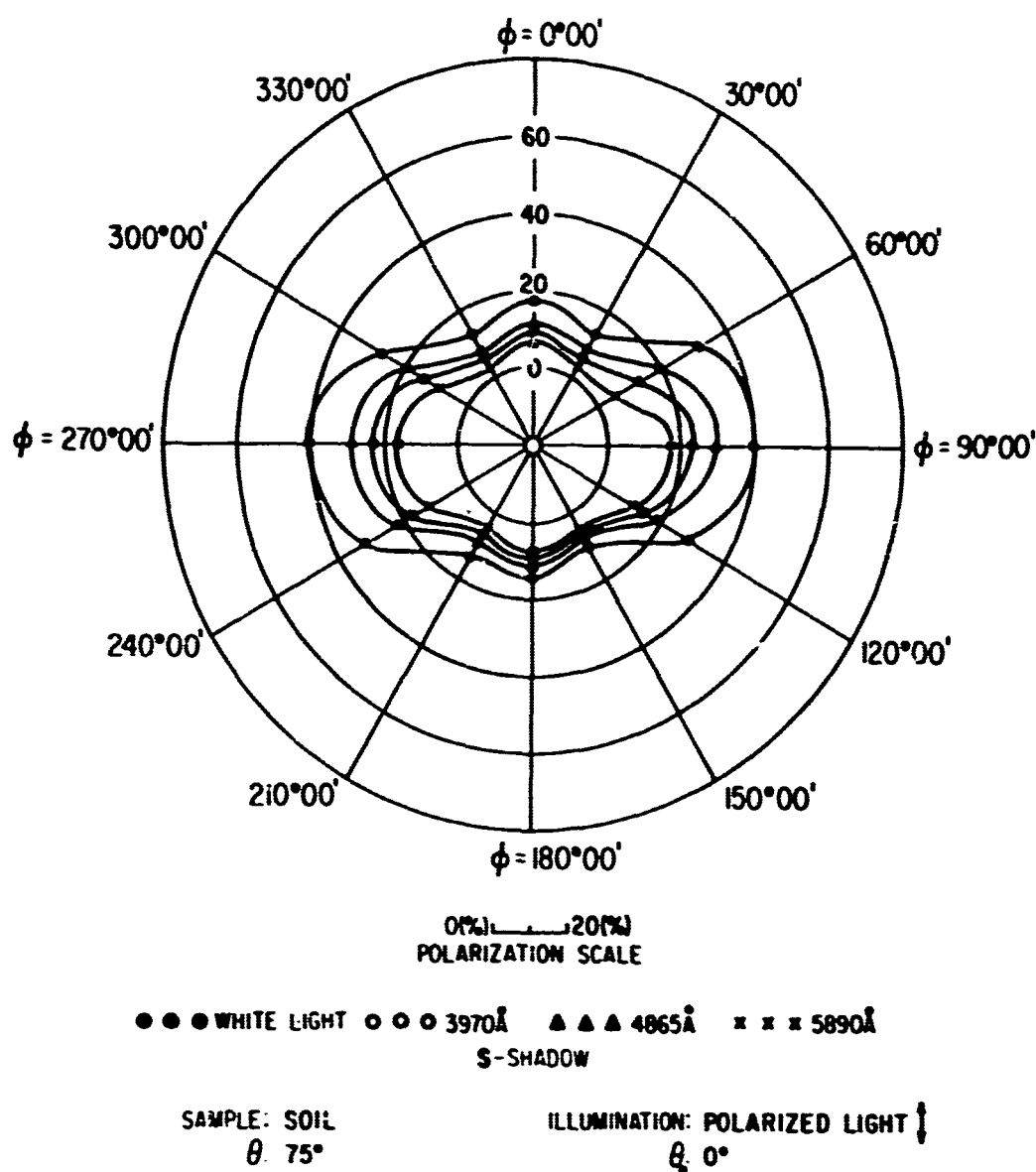


FIG. 241. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 13.22 + 0.71 \cos \phi - 6.91 \cos 2\phi + 0.20 \cos 3\phi + 2.69 \cos 4\phi - 0.96 \cos 5\phi \\
 & + 1.10 \cos 6\phi - 0.63 \sin \phi + 0.30 \sin 2\phi - 1.10 \sin 3\phi - 2.04 \sin 4\phi - 0.54 \sin 5\phi
 \end{aligned}$$

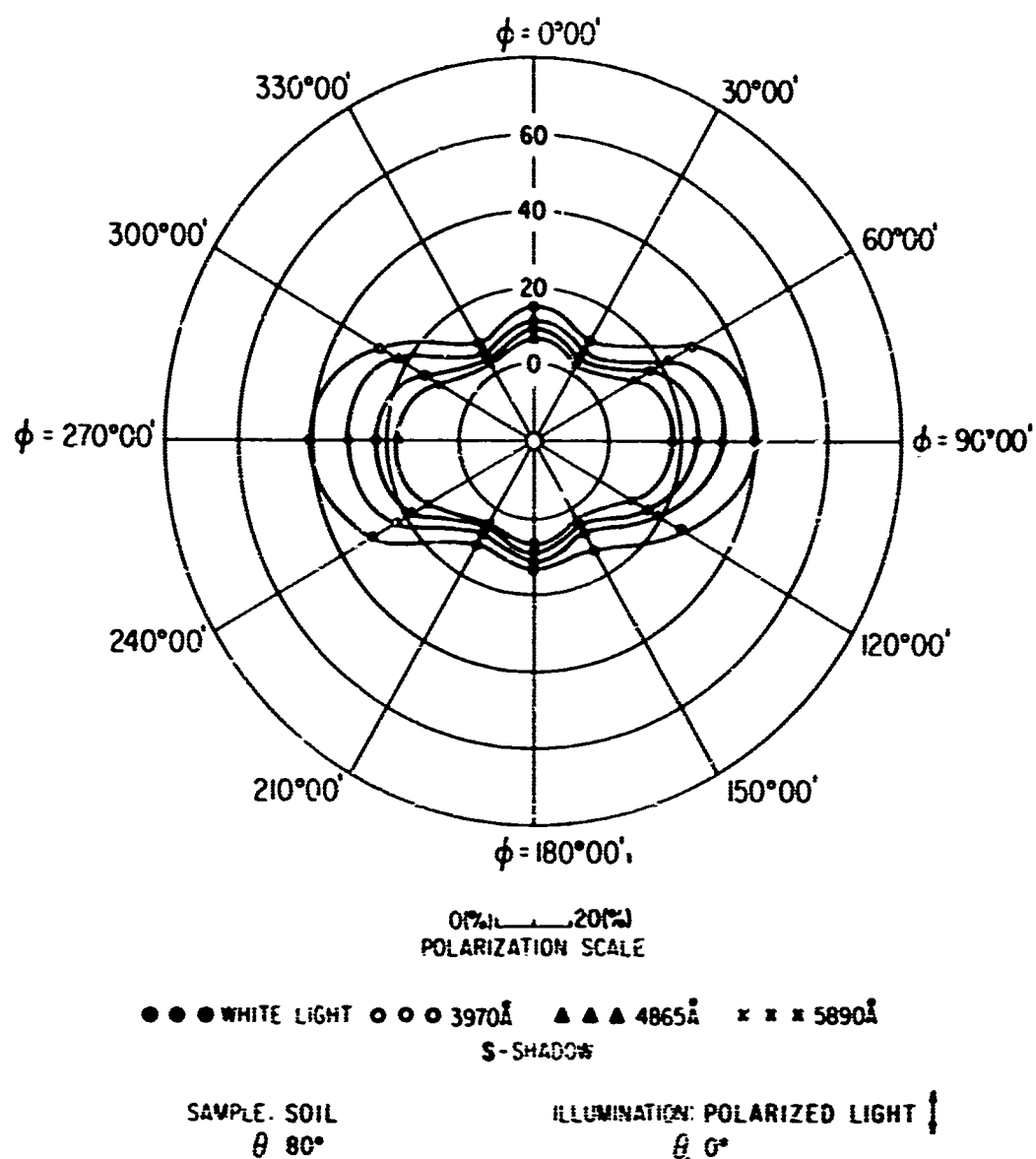


FIG. 242. POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 12.79 - 1.02 \cos \phi - 8.05 \cos 2\phi + 0.40 \cos 3\phi + 3.38 \cos 4\phi + 0.29 \cos 5\phi \\
 & + 2.95 \cos 6\phi + 0.04 \sin \phi + 1.52 \sin 2\phi - 0.98 \sin 3\phi + 0.03 \sin 4\phi - 0.77 \sin 5\phi
 \end{aligned}$$

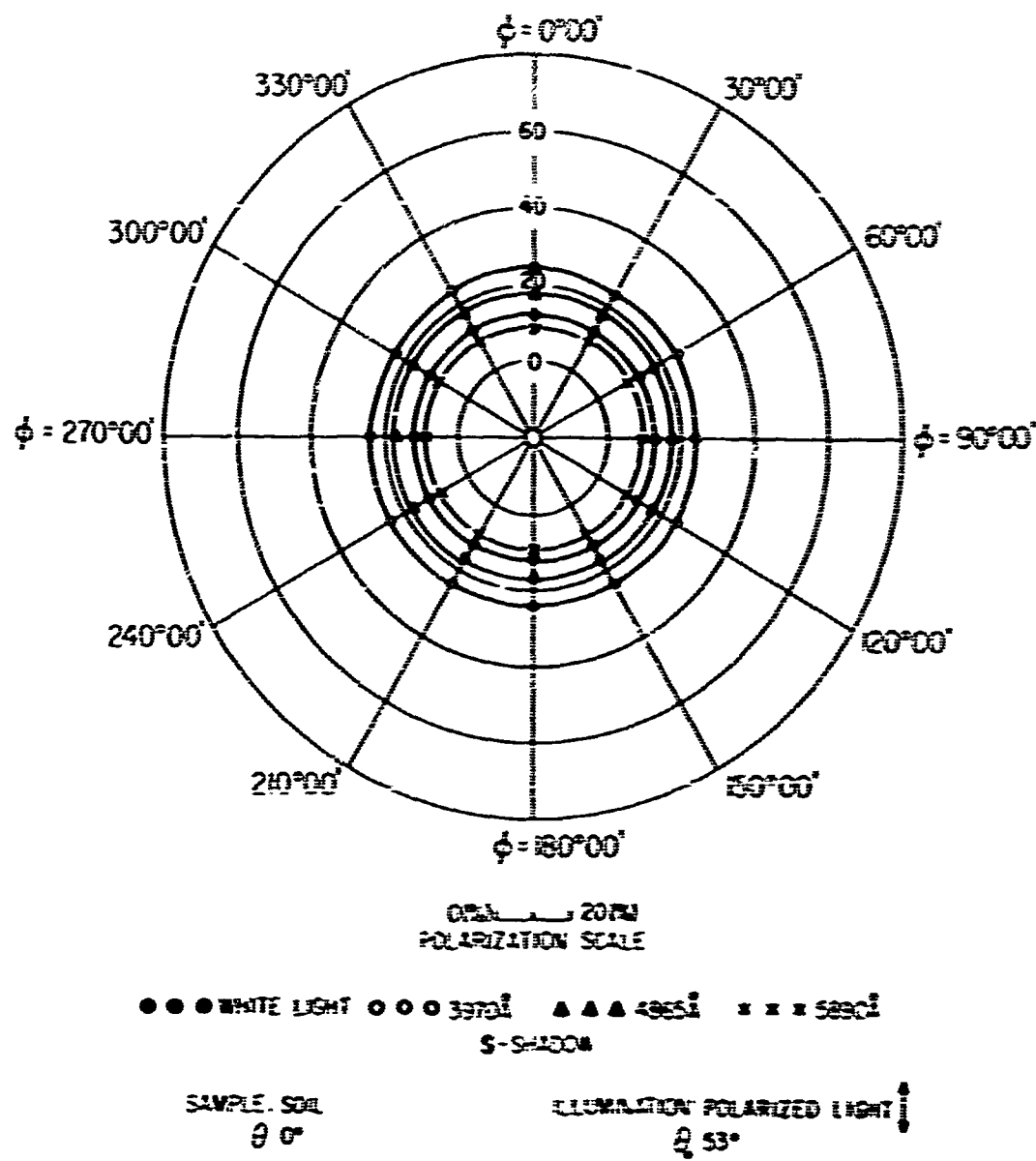


FIG 243 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

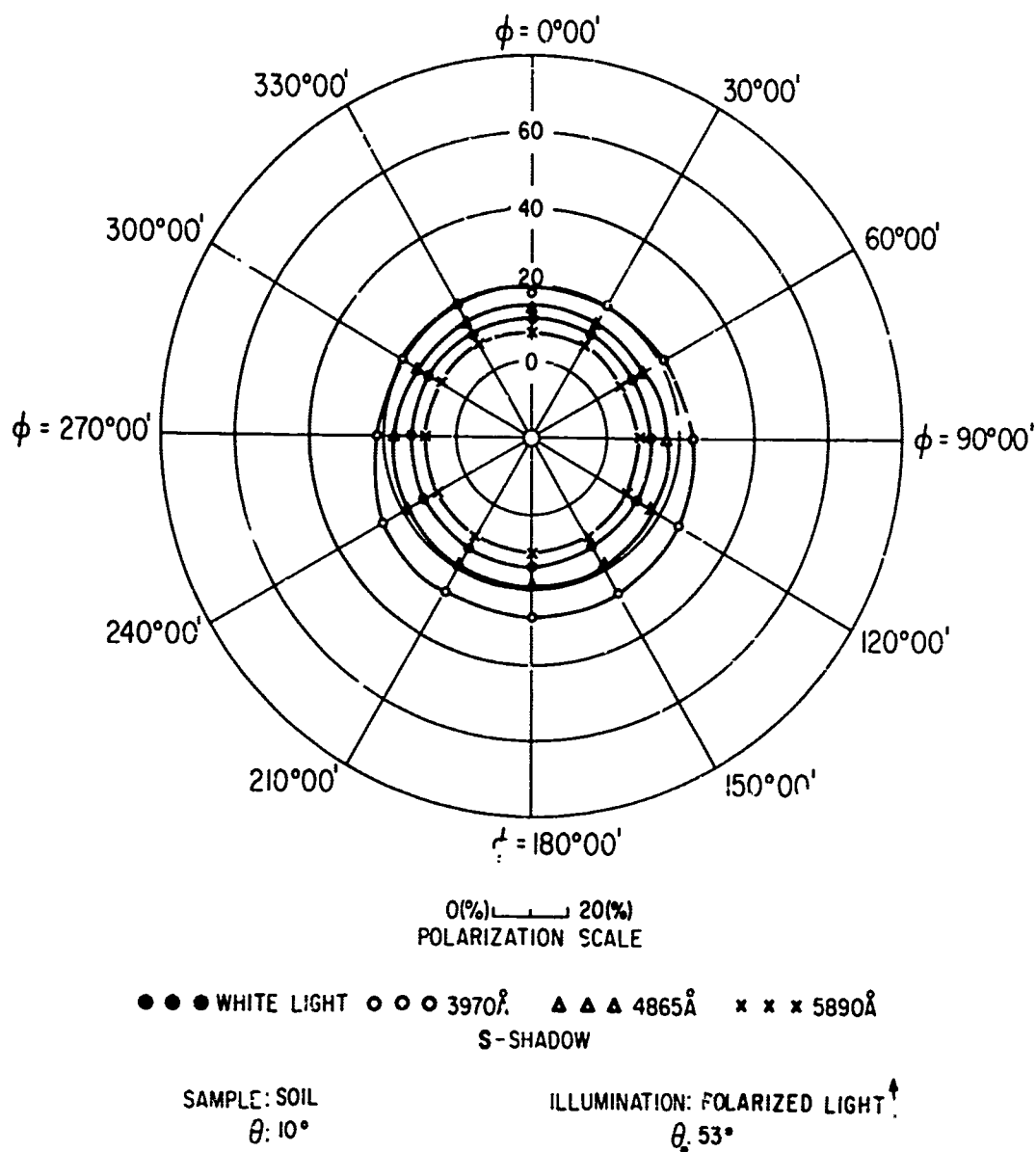


FIG.244 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 12.33 - 1.94 \cos \phi + 0.05 \cos 2\phi + 0.07 \cos 3\phi - 0.08 \cos 4\phi - 0.03 \cos 5\phi \\
 & + 0.20 \cos 6\phi - 0.29 \sin \phi - 0.06 \sin 2\phi - 0.13 \sin 3\phi - 0.06 \sin 4\phi + 0.06 \sin 5\phi
 \end{aligned}$$

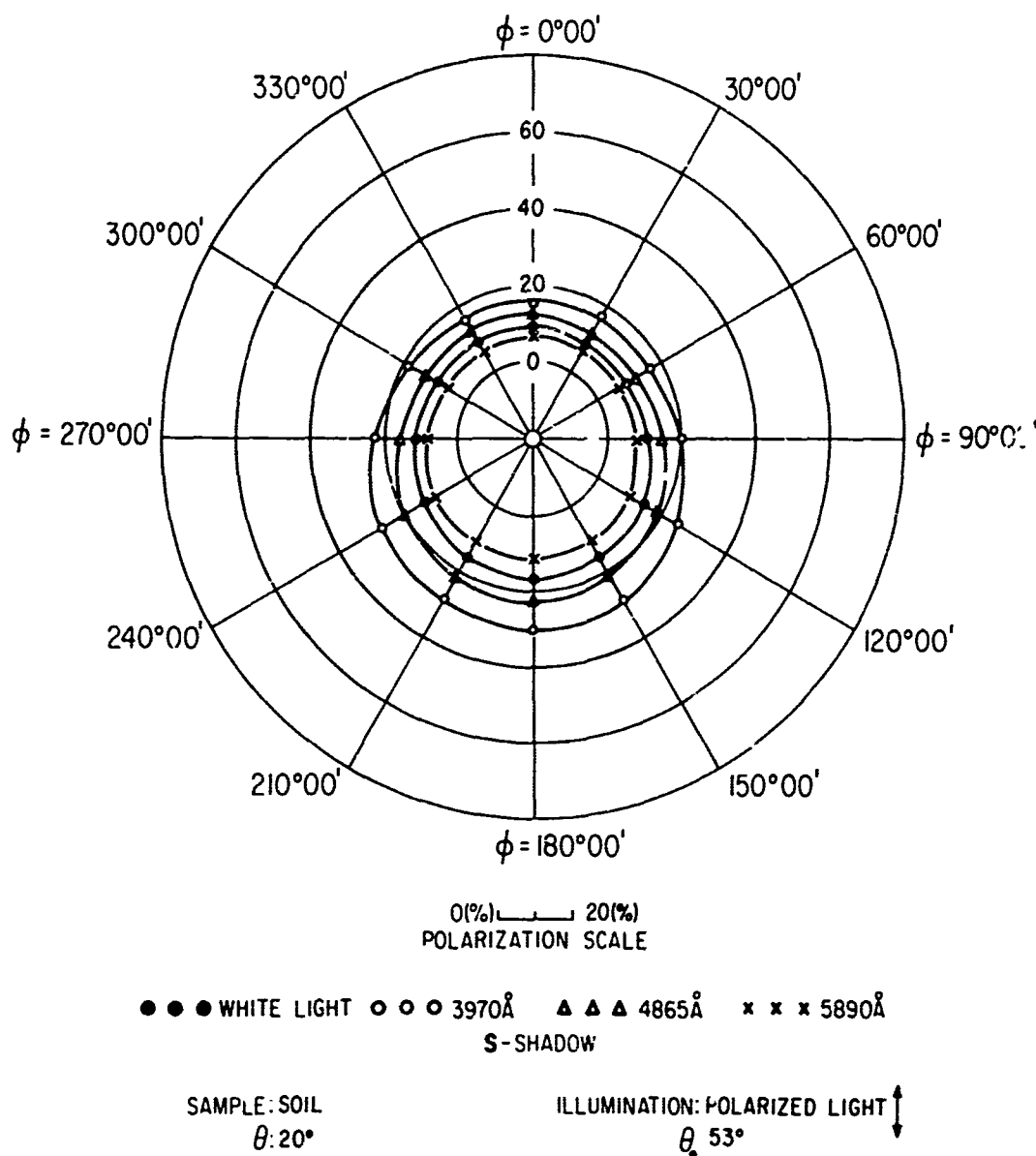


FIG.245 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\varphi) = 12.02 - 3.99 \cos \varphi + 0.97 \cos 2\varphi + 0.37 \cos 3\varphi + 0.15 \cos 4\varphi + 0.08 \cos 5\varphi \\ + 0.22 \cos 6\varphi - 0.23 \sin \varphi - 0.20 \sin 2\varphi - 0.12 \sin 3\varphi + 0.06 \sin 4\varphi - 0.08 \sin 5\varphi$$

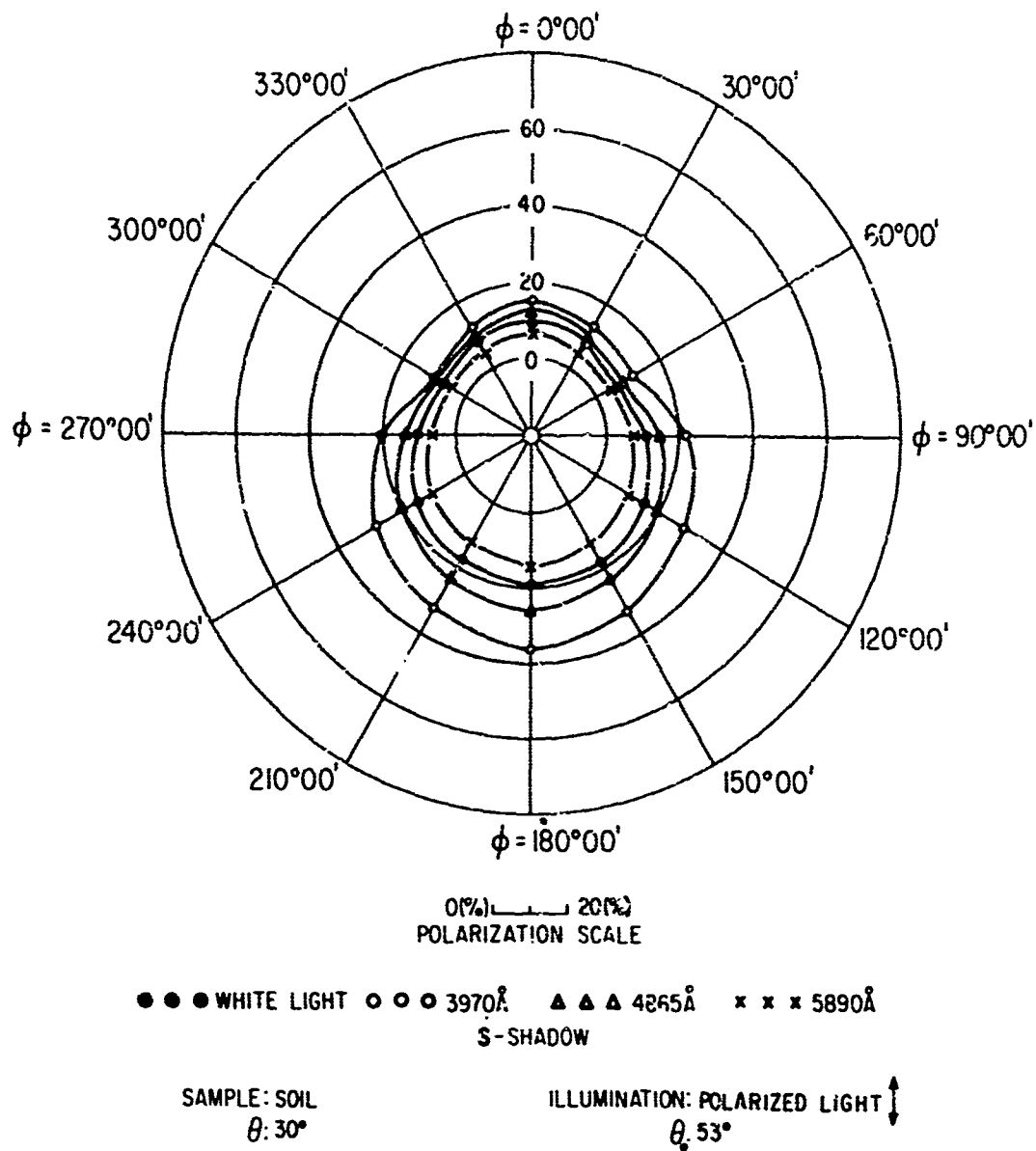


FIG.246 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 12.20 - 6.08 \cos \varphi + 2.09 \cos 2\varphi + 1.25 \cos 3\varphi + 0.58 \cos 4\varphi - 0.36 \cos 5\varphi \\
 & - 0.23 \cos 6\varphi + 0.05 \sin \varphi - 0.10 \sin 2\varphi + 0.02 \sin 3\varphi + 0.01 \sin 4\varphi + 0.09 \sin 5\varphi
 \end{aligned}$$

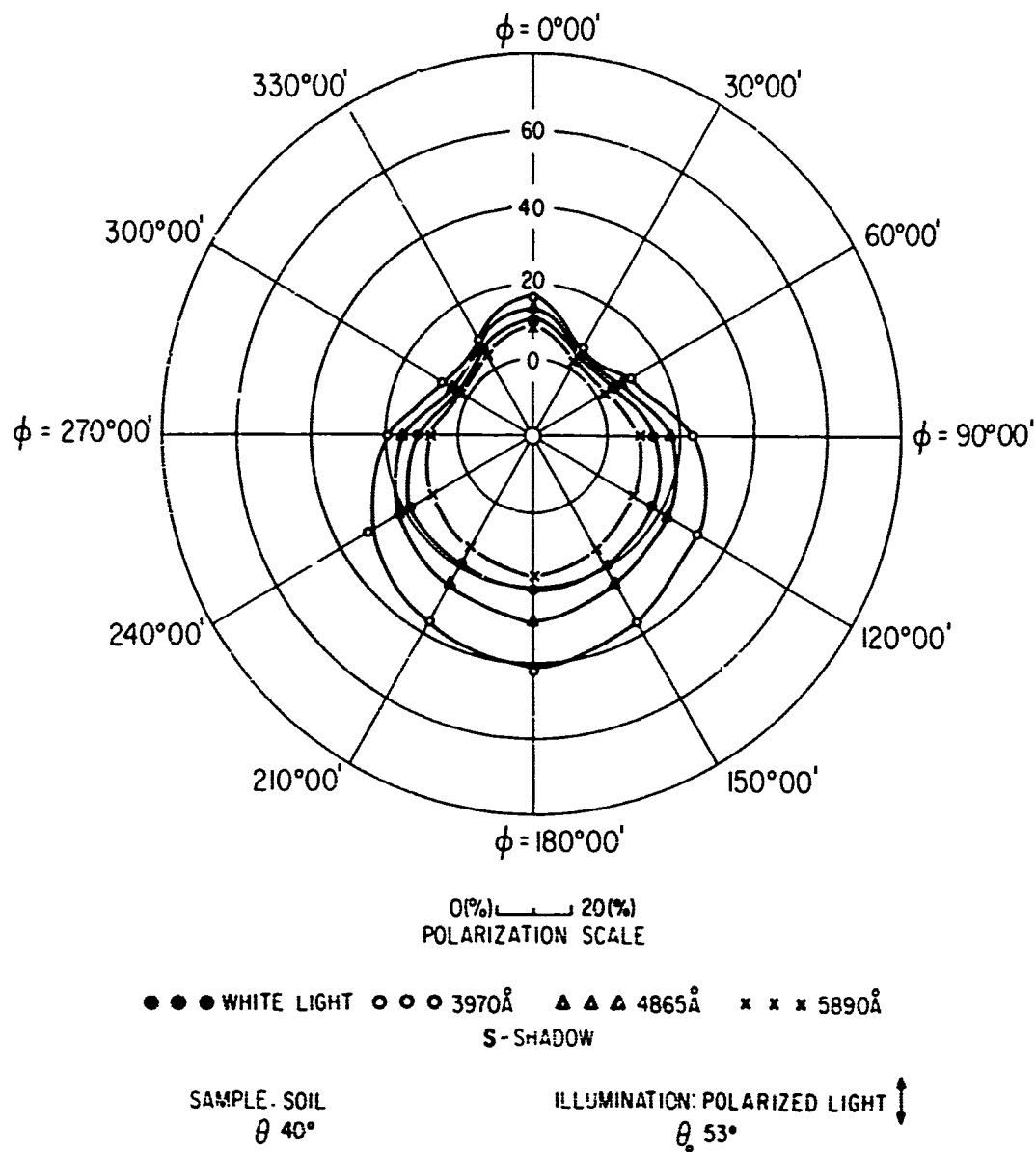


FIG 247 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 12.13 - 7.73 \cos \phi + 2.16 \cos 2\phi + 2.27 \cos 3\phi - 1.64 \cos 4\phi + 0.27 \cos 5\phi \\
 & - 0.07 \cos 6\phi - 0.25 \sin \phi + 0.46 \sin 2\phi - 0.66 \sin 3\phi - 1.07 \sin 4\phi + 0.24 \sin 5\phi
 \end{aligned}$$

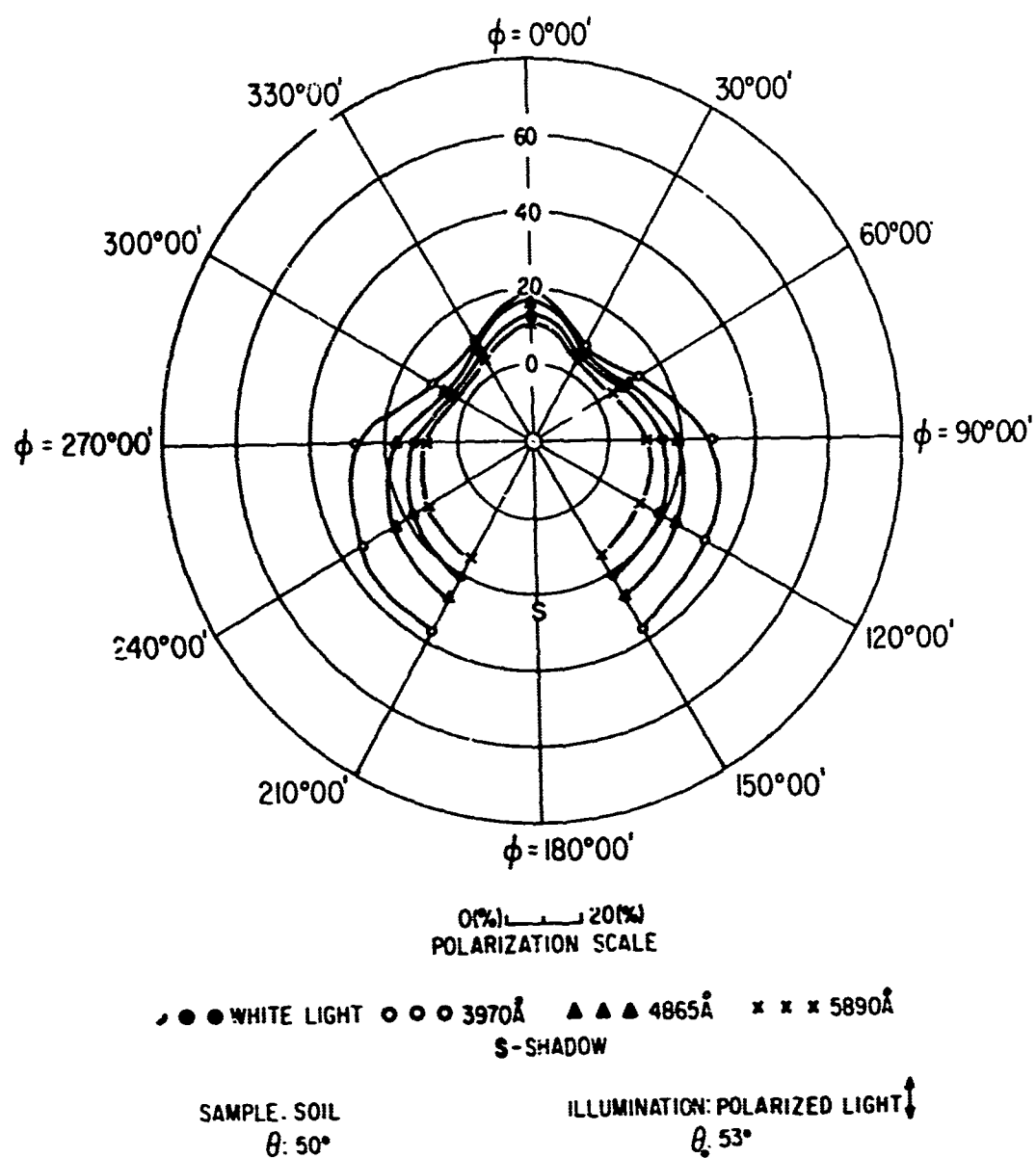


FIG. 248 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 13.59 - 7.16 \cos \varphi + 1.75 \cos 2\varphi + 2.52 \cos 3\varphi + 1.73 \cos 4\varphi + 0.84 \cos 5\varphi \\
 & - 0.84 \cos 6\varphi + 0.99 \sin \varphi + 0.23 \sin 2\varphi + 0.63 \sin 3\varphi - 0.60 \sin 4\varphi - 0.37 \sin 5\varphi
 \end{aligned}$$

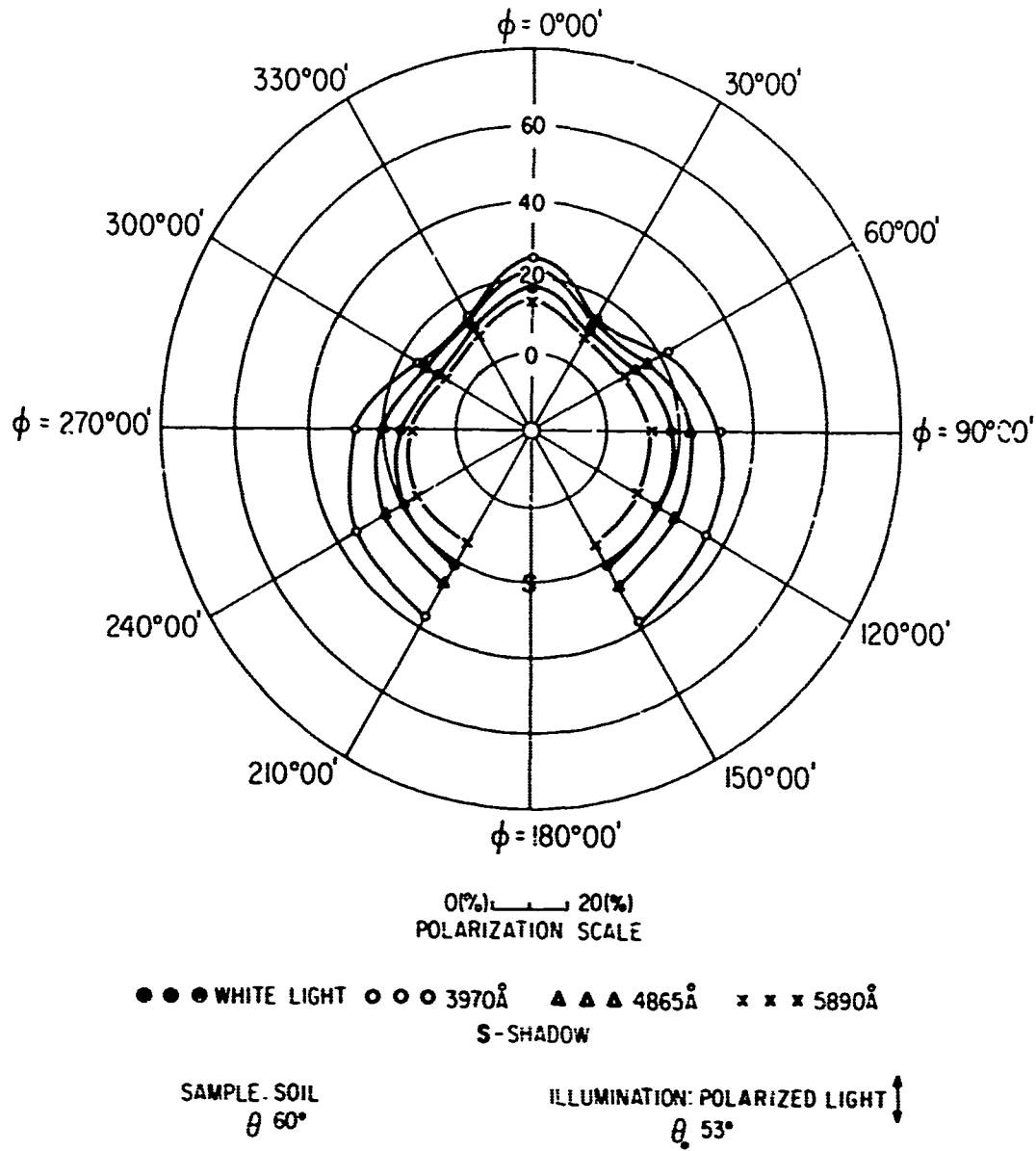


FIG249 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 14.52 - 4.83 \cos \phi + 1.39 \cos 2\phi + 2.20 \cos 3\phi + 3.69 \cos 4\phi + 0.86 \cos 5\phi \\
 & + 0.42 \cos 6\phi + 0.78 \sin \phi + 0.45 \sin 2\phi - 0.47 \sin 3\phi - 0.42 \sin 4\phi - 0.20 \sin 5\phi
 \end{aligned}$$

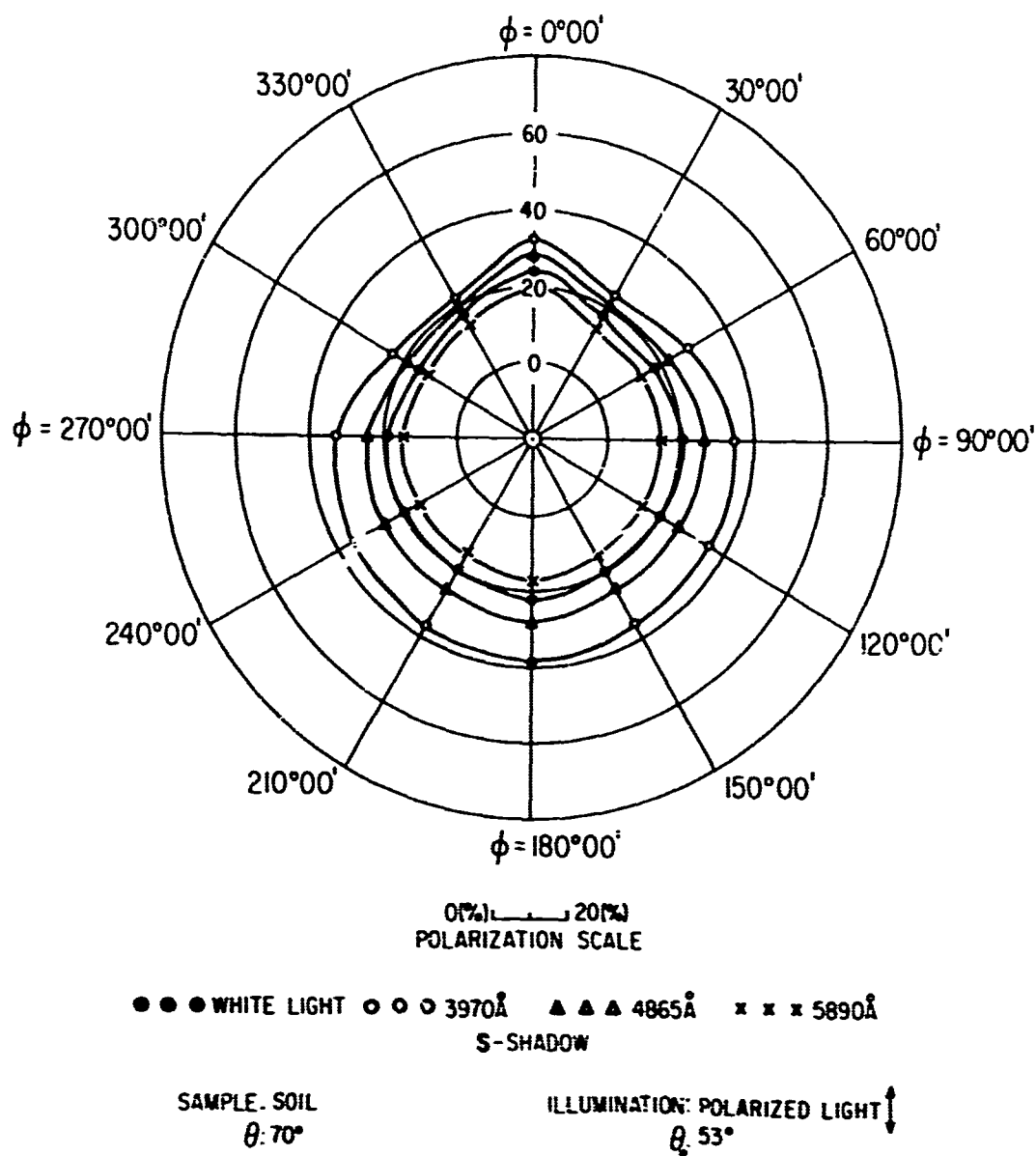
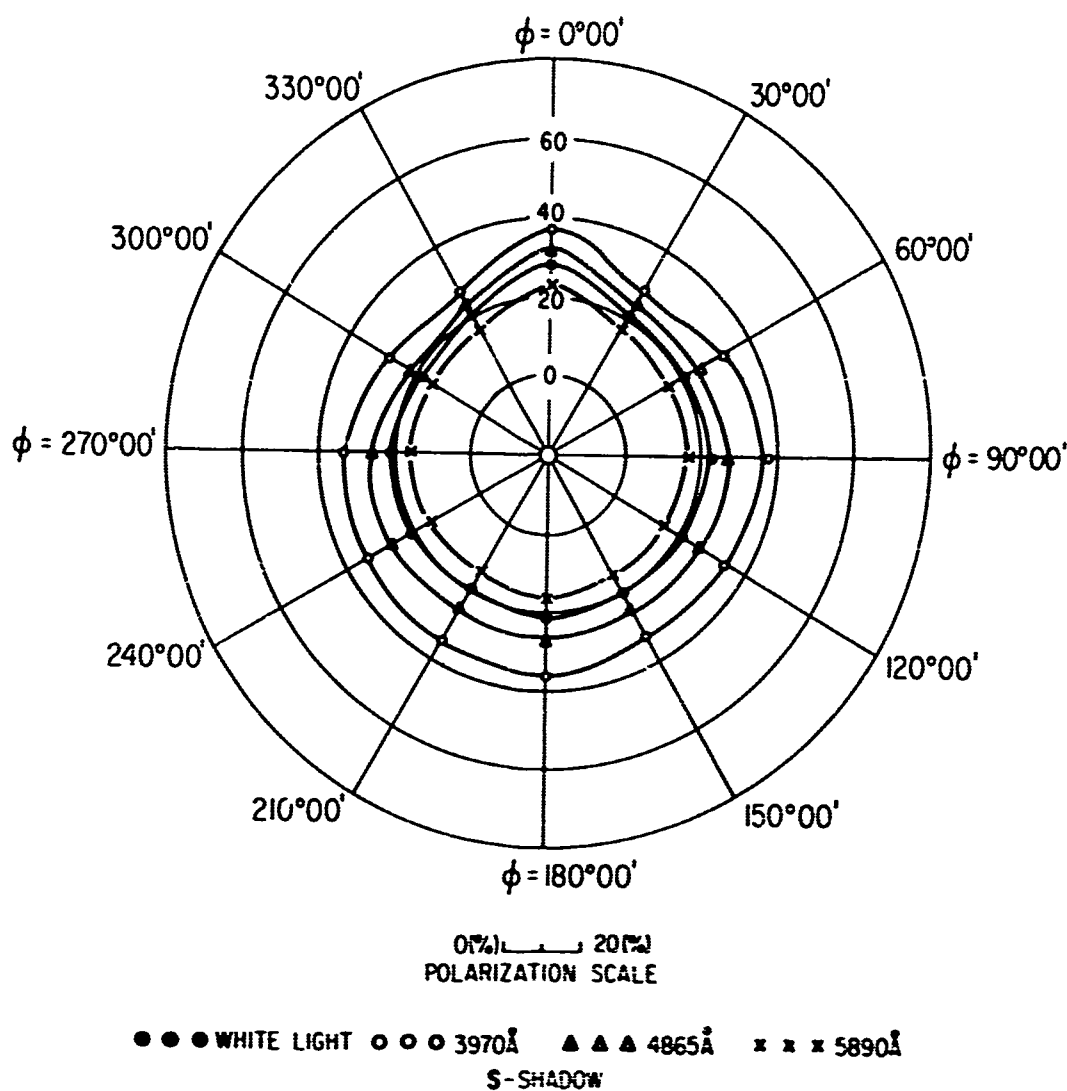


FIG 250 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 19.58 - 0.88 \cos \phi + 1.51 \cos 2\phi + 1.27 \cos 3\phi + 2.06 \cos 4\phi + 0.31 \cos 5\phi \\
 & + 0.73 \cos 6\phi + 0.01 \sin \phi - 0.03 \sin 2\phi - 0.30 \sin 3\phi + 0.29 \sin 4\phi + 0.33 \sin 5\phi
 \end{aligned}$$



SAMPLE SOIL
 $\theta: 75^\circ$

ILLUMINATION: POLARIZED LIGHT \updownarrow
 $\theta: 53^\circ$

FIG.251 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 21.21 + 1.73 \cos \phi + 1.15 \cos 2\phi + 1.37 \cos 3\phi + 2.07 \cos 4\phi + 0.36 \cos 5\phi \\ - 0.85 \cos 6\phi + 0.54 \sin \phi + 0.49 \sin 2\phi - 0.35 \sin 3\phi - 0.17 \sin 4\phi - 0.19 \sin 5\phi$$

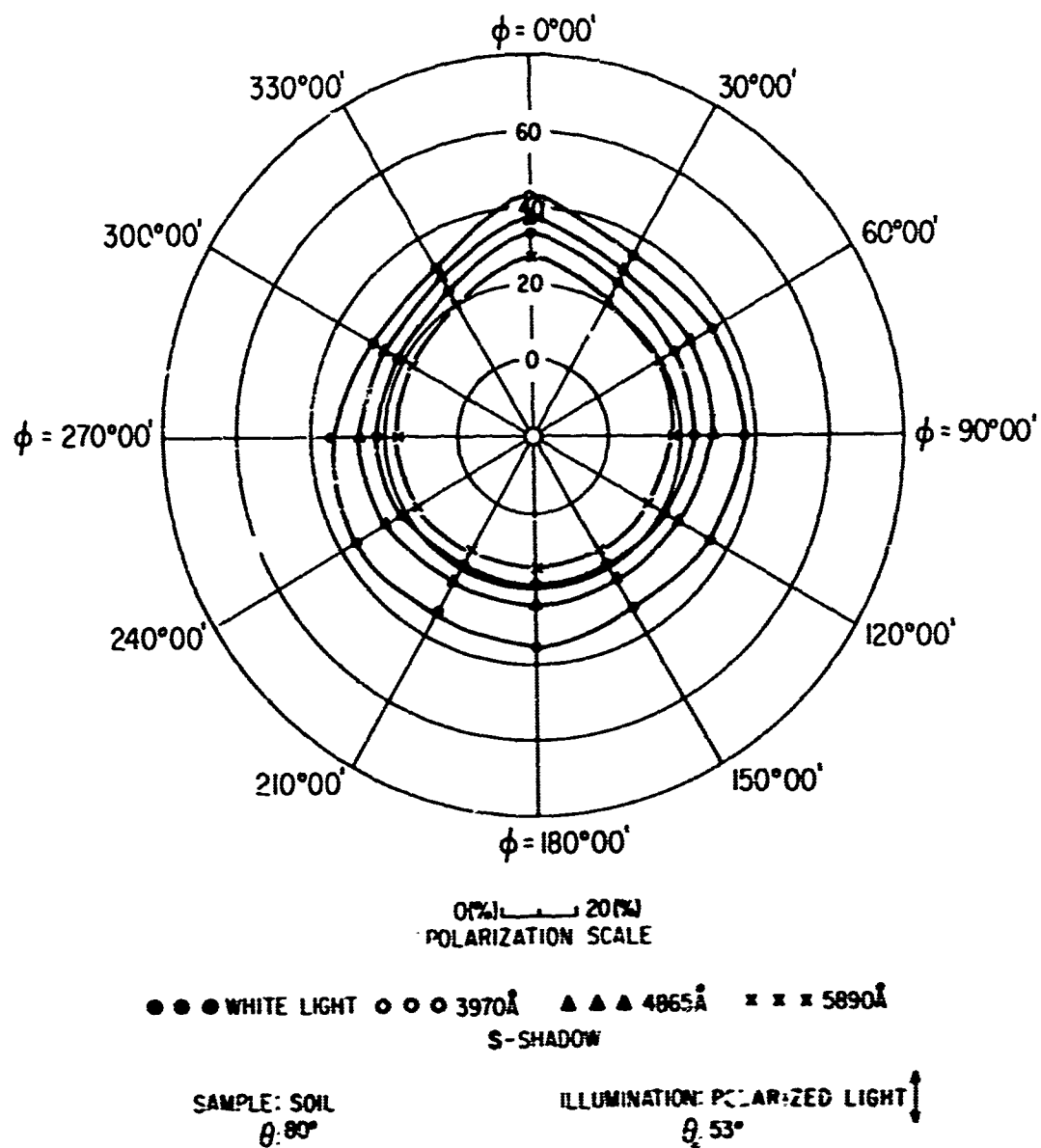


FIG.252 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 22.82 + 4.49 \cos \phi + 1.33 \cos 2\phi + 1.47 \cos 3\phi + 1.90 \cos 4\phi + 0.74 \cos 5\phi \\
 & + 1.28 \cos 6\phi - 0.64 \sin \phi + 0.96 \sin 2\phi - 0.05 \sin 3\phi + 0.03 \sin 4\phi + 0.06 \sin 5\phi
 \end{aligned}$$

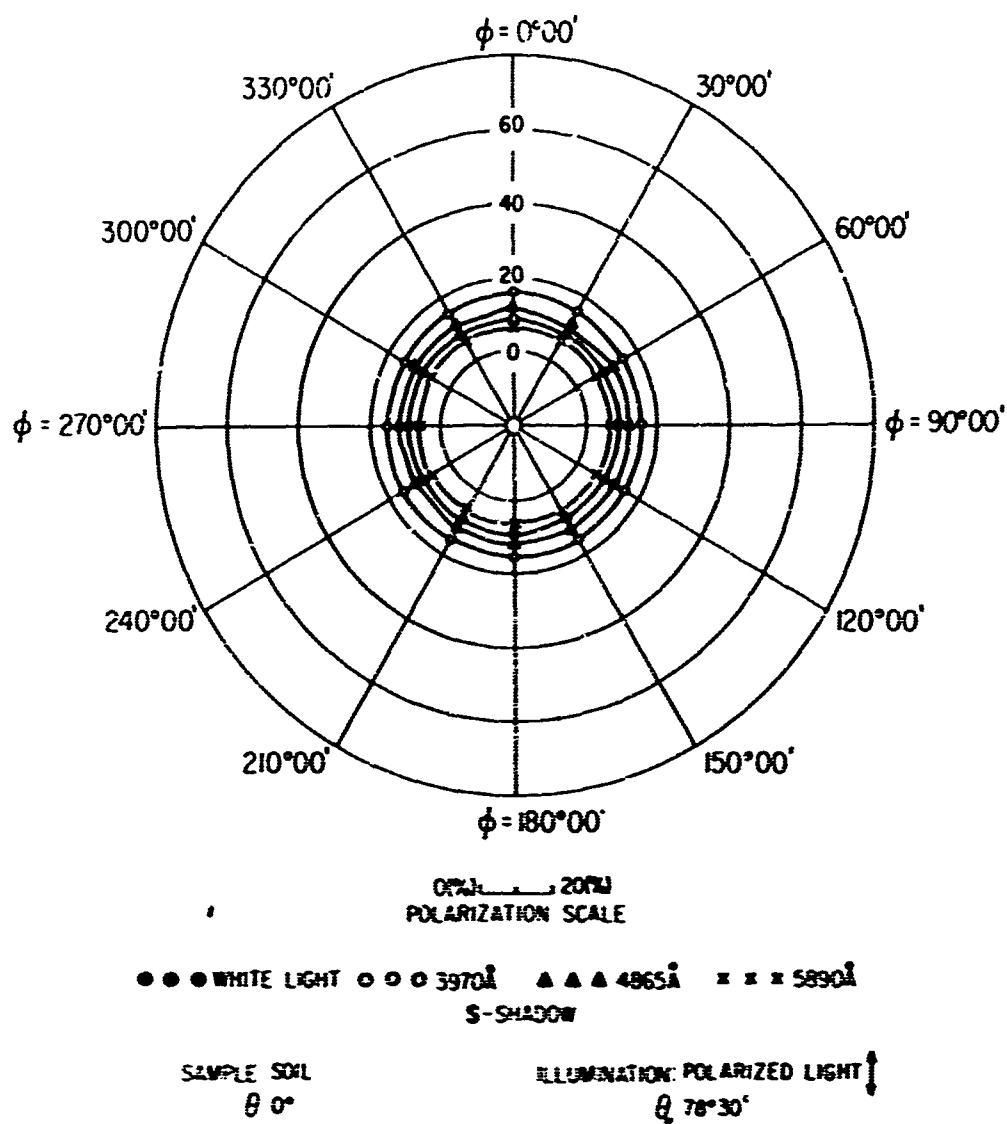


FIG 253 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

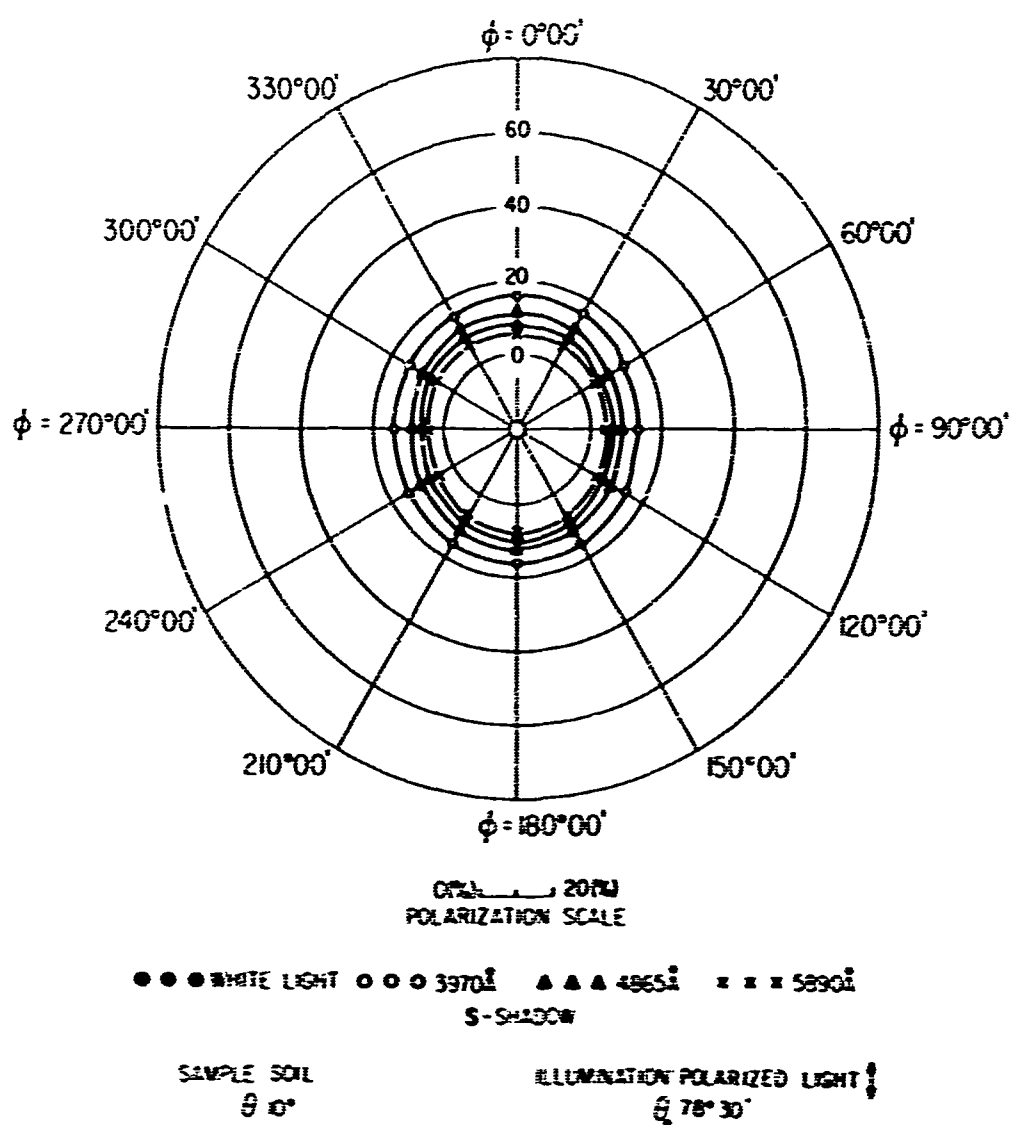


FIG 254 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 8.56 - 0.10 \cos \phi + 0.54 \cos 2\phi + 0.03 \cos 3\phi - 0.06 \cos 4\phi + 0.01 \cos 5\phi \\
 & + 0.02 \cos 6\phi - 1.24 \sin \phi - 0.13 \sin 2\phi + 0.02 \sin 3\phi - 0.04 \sin 4\phi + 0.00 \sin 5\phi
 \end{aligned}$$

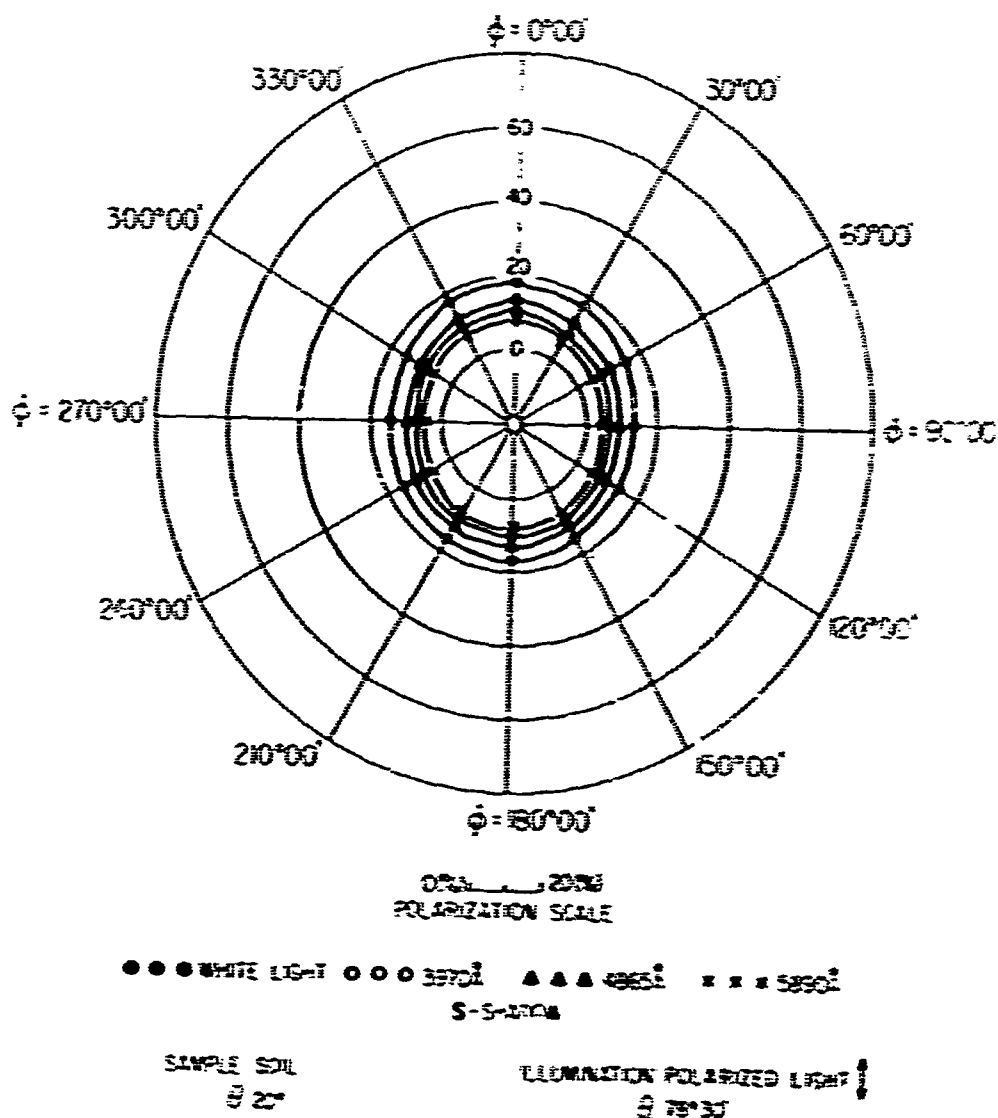


FIG 255 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$P(\phi) = 8.72 - 0.10 \cos \phi + 2.13 \cos 2\phi - 0.17 \cos 3\phi + 0.23 \cos 4\phi + 0.13 \cos 5\phi \\ + 0.23 \cos 6\phi - 1.02 \sin \phi - 0.11 \sin 2\phi - 0.33 \sin 3\phi - 0.29 \sin 4\phi + 0.08 \sin 5\phi$$

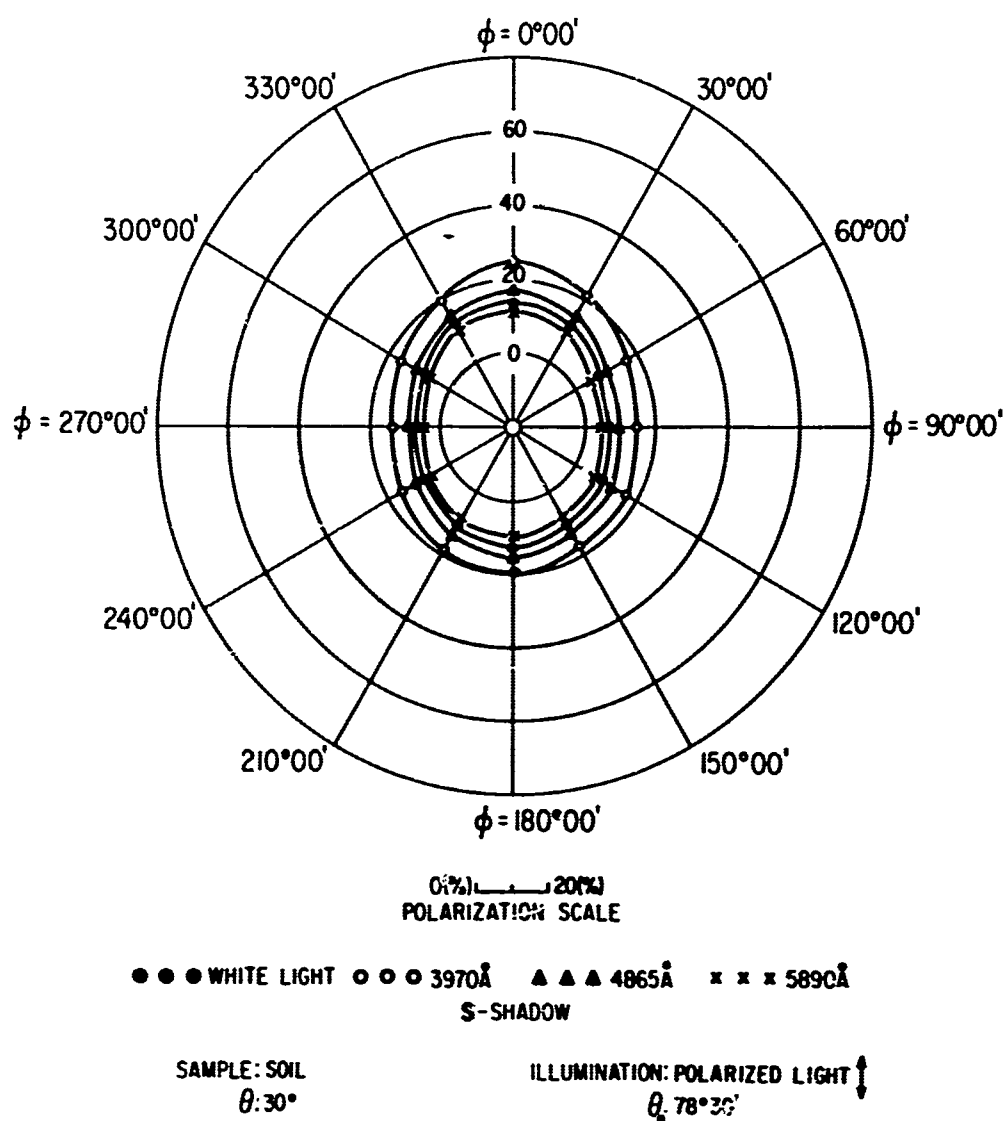


FIG.256 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 9.24 + 0.16 \cos \varphi + 3.89 \cos 2\varphi + 0.88 \cos 3\varphi + 0.81 \cos 4\varphi + 0.01 \cos 5\varphi \\
 & + 0.18 \cos 6\varphi - 0.22 \sin \varphi - 0.42 \sin 2\varphi - 0.43 \sin 3\varphi - 0.24 \sin 4\varphi - 0.13 \sin 5\varphi
 \end{aligned}$$

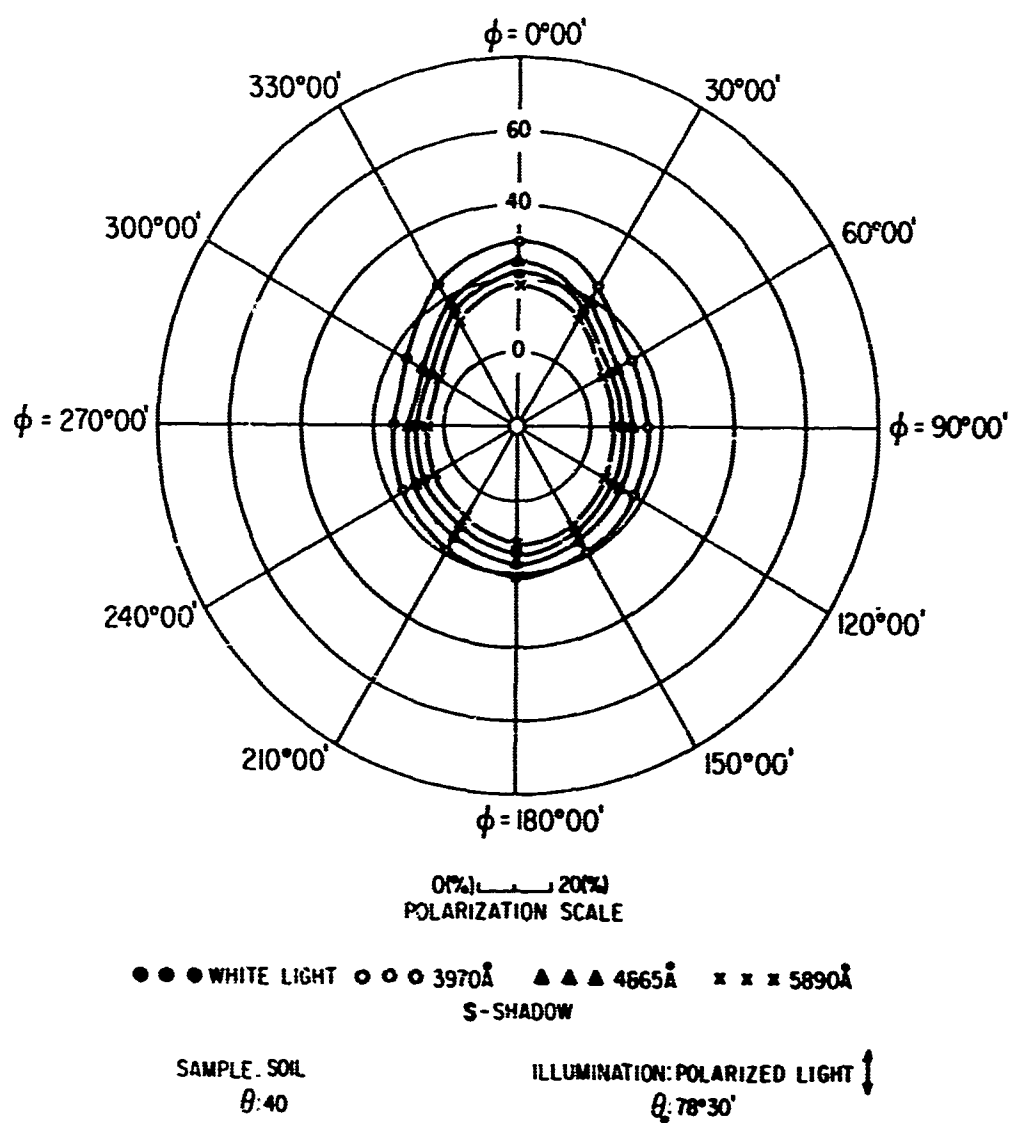
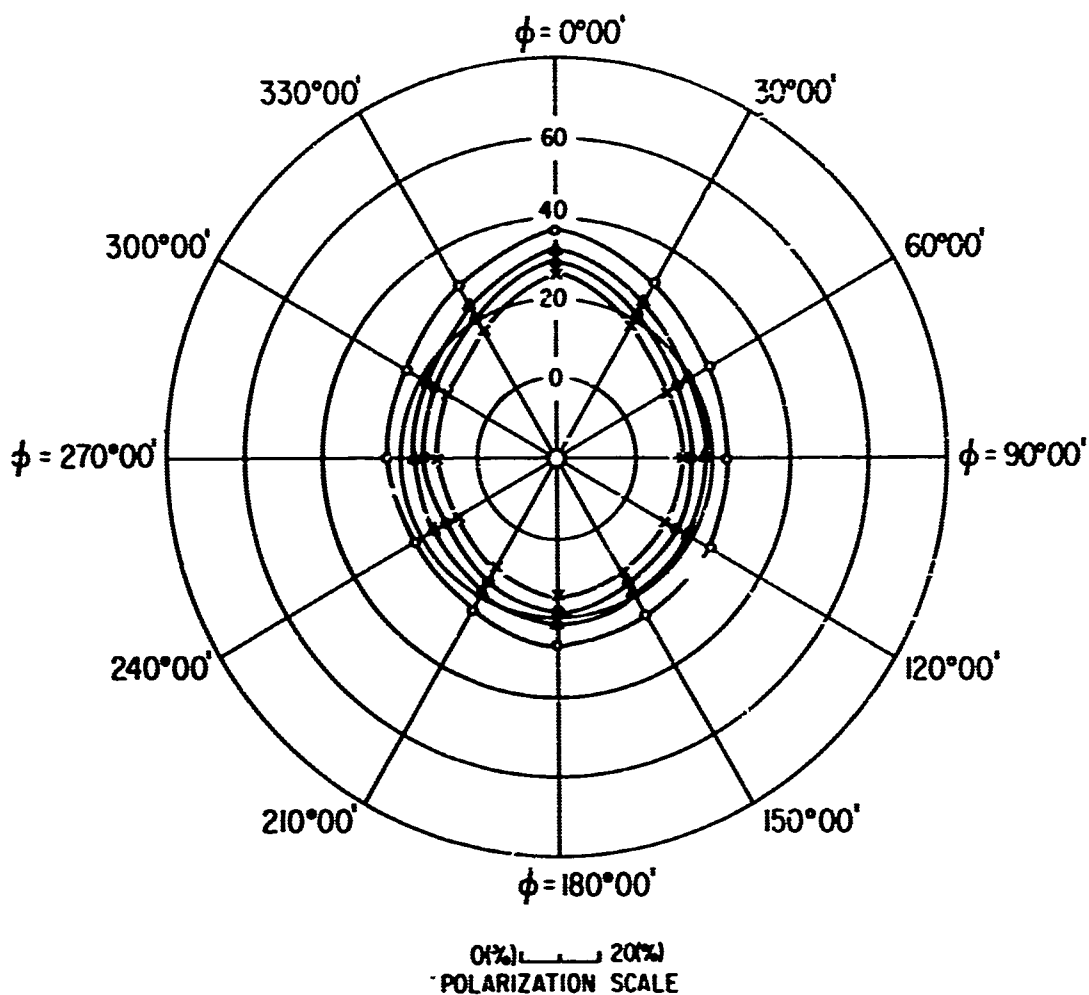


FIG. 257 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 12.38 + 1.13 \cos \varphi + 5.29 \cos 2\varphi + 1.60 \cos 3\varphi + 1.08 \cos 4\varphi - 0.07 \cos 5\varphi \\
 & - 0.48 \cos 6\varphi + 0.84 \sin \varphi - 0.22 \sin 2\varphi - 0.22 \sin 3\varphi - 0.16 \sin 4\varphi - 0.66 \sin 5\varphi
 \end{aligned}$$



● ● ● WHITE LIGHT ○ ○ ○ 3970Å ▲ ▲ ▲ 4865Å × × × 5890Å
 S-SHADOW

SAMPLE: SOIL
 $\theta: 50^\circ$

ILLUMINATION: POLARIZED LIGHT \updownarrow
 $\theta: 78^\circ 30'$

FIG.258 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 17.62 + 3.79 \cos \varphi + 4.36 \cos 2\varphi + 0.73 \cos 3\varphi + 2.16 \cos 4\varphi + 0.73 \cos 5\varphi \\
 & - 0.30 \cos 6\varphi + 0.34 \sin \varphi - 0.65 \sin 2\varphi + 0.77 \sin 3\varphi + 0.59 \sin 4\varphi - 0.67 \sin 5\varphi
 \end{aligned}$$

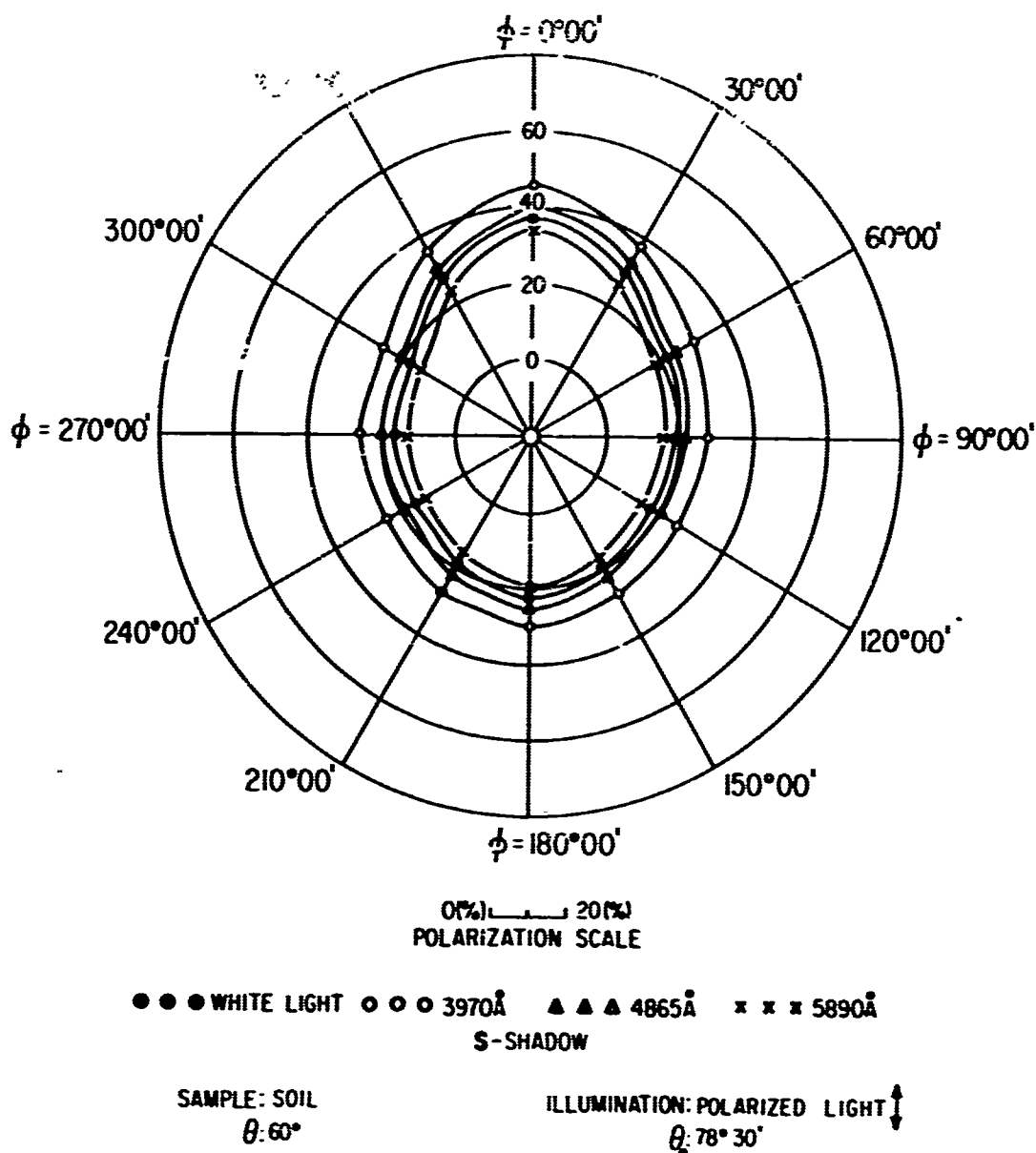


FIG.259 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 21.98 + 6.14 \cos \varphi + 6.46 \cos 2\varphi + 1.57 \cos 3\varphi + 2.22 \cos 4\varphi + 0.14 \cos 5\varphi \\
 & + 0.18 \cos 6\varphi + 1.81 \sin \varphi + 0.30 \sin 2\varphi + 0.05 \sin 3\varphi - 0.19 \sin 4\varphi - 0.71 \sin 5\varphi
 \end{aligned}$$

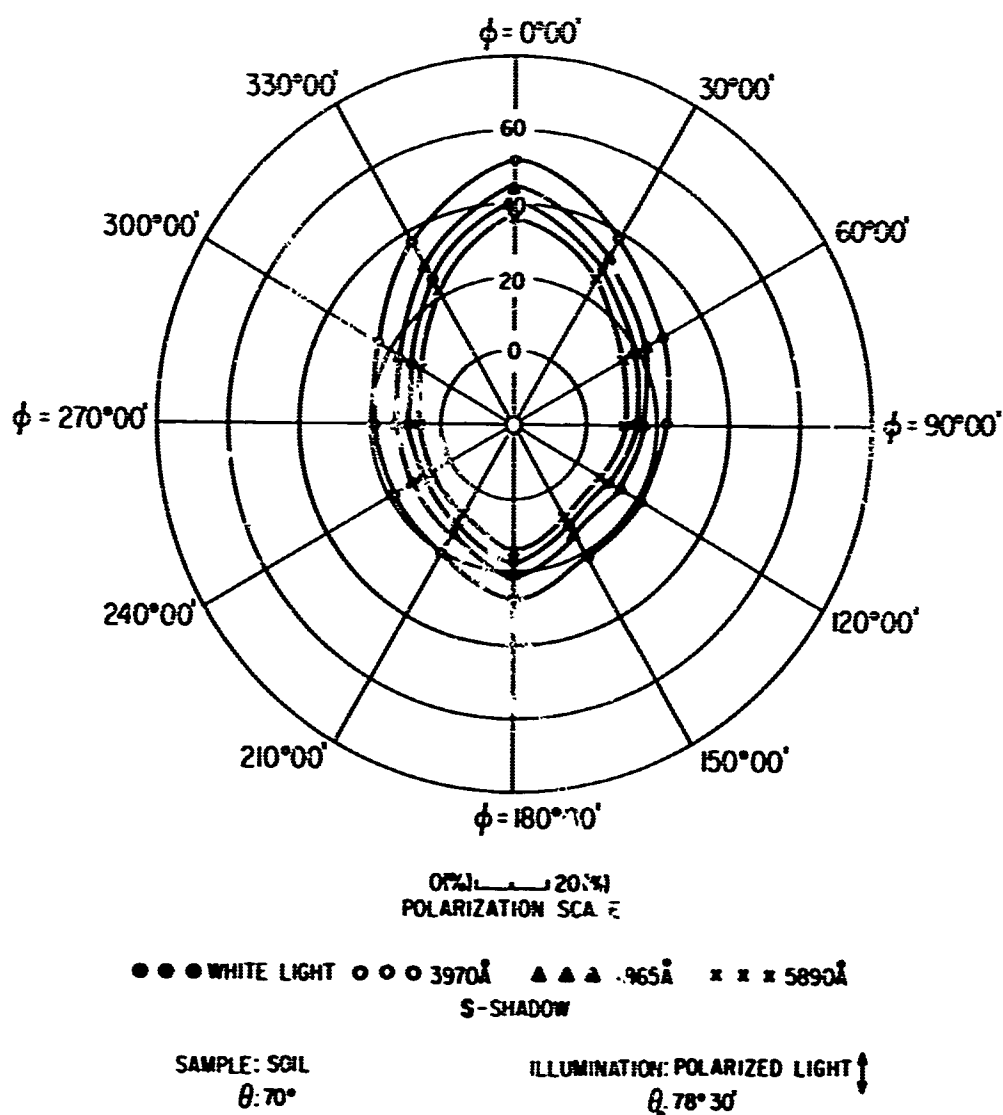


FIG. 260 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\varphi) = & 18.78 + 9.52 \cos \varphi + 6.65 \cos 2\varphi + 1.35 \cos 3\varphi + 2.85 \cos 4\varphi + 0.18 \cos 5\varphi \\
 & + 1.35 \cos 6\varphi + 0.00 \sin \varphi + 0.00 \sin 2\varphi + 0.00 \sin 3\varphi + 0.00 \sin 4\varphi + 0.00 \sin 5\varphi
 \end{aligned}$$

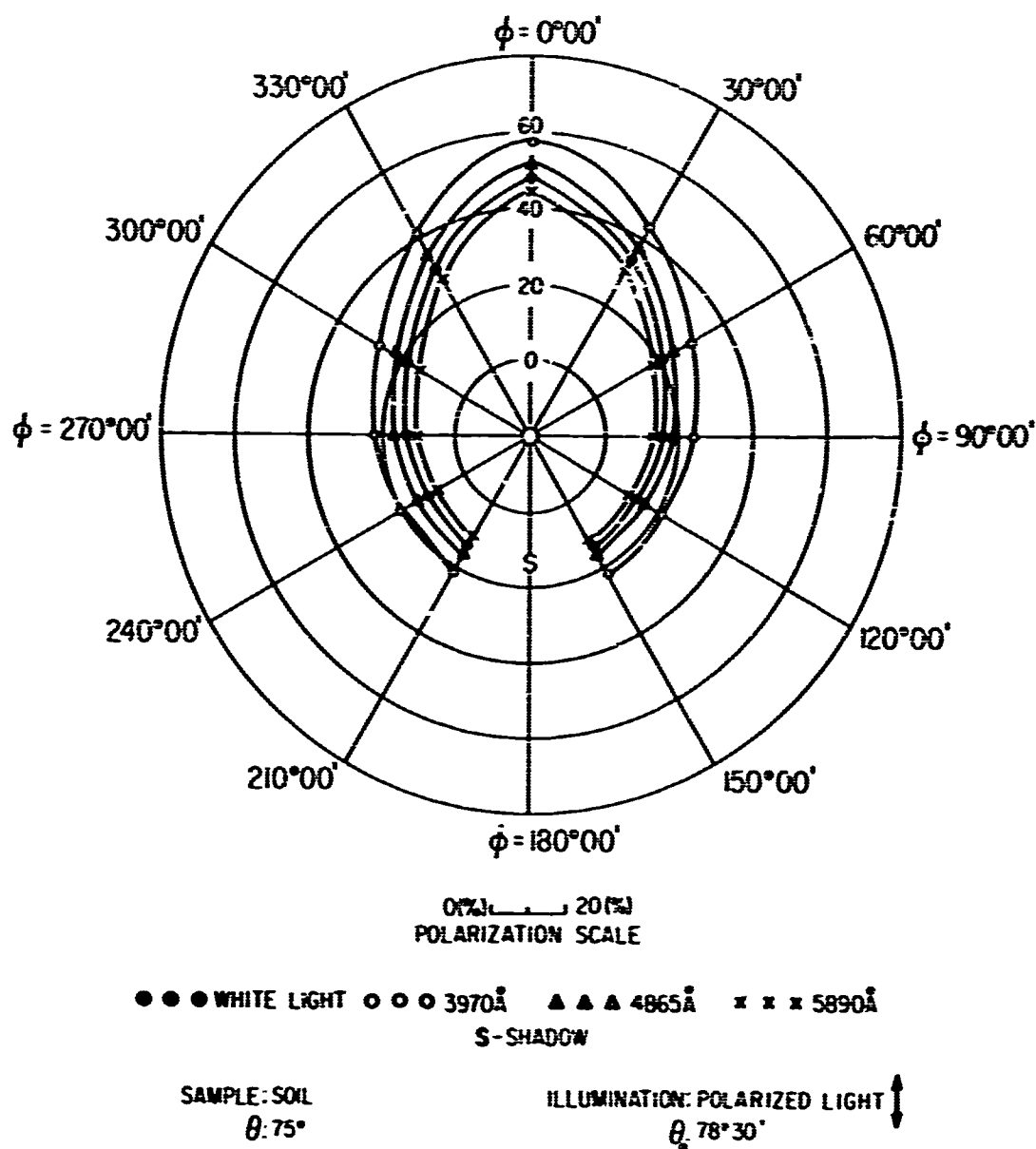


FIG.26I POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION
OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 19.70 + 9.97 \cos \phi + 6.01 \cos 2\phi + 3.15 \cos 3\phi + 3.42 \cos 4\phi + 3.93 \cos 5\phi \\
 & + 3.83 \cos 6\phi + 0.10 \sin \phi - 0.04 \sin 2\phi - 0.08 \sin 3\phi - 0.10 \sin 4\phi - 0.08 \sin 5\phi
 \end{aligned}$$

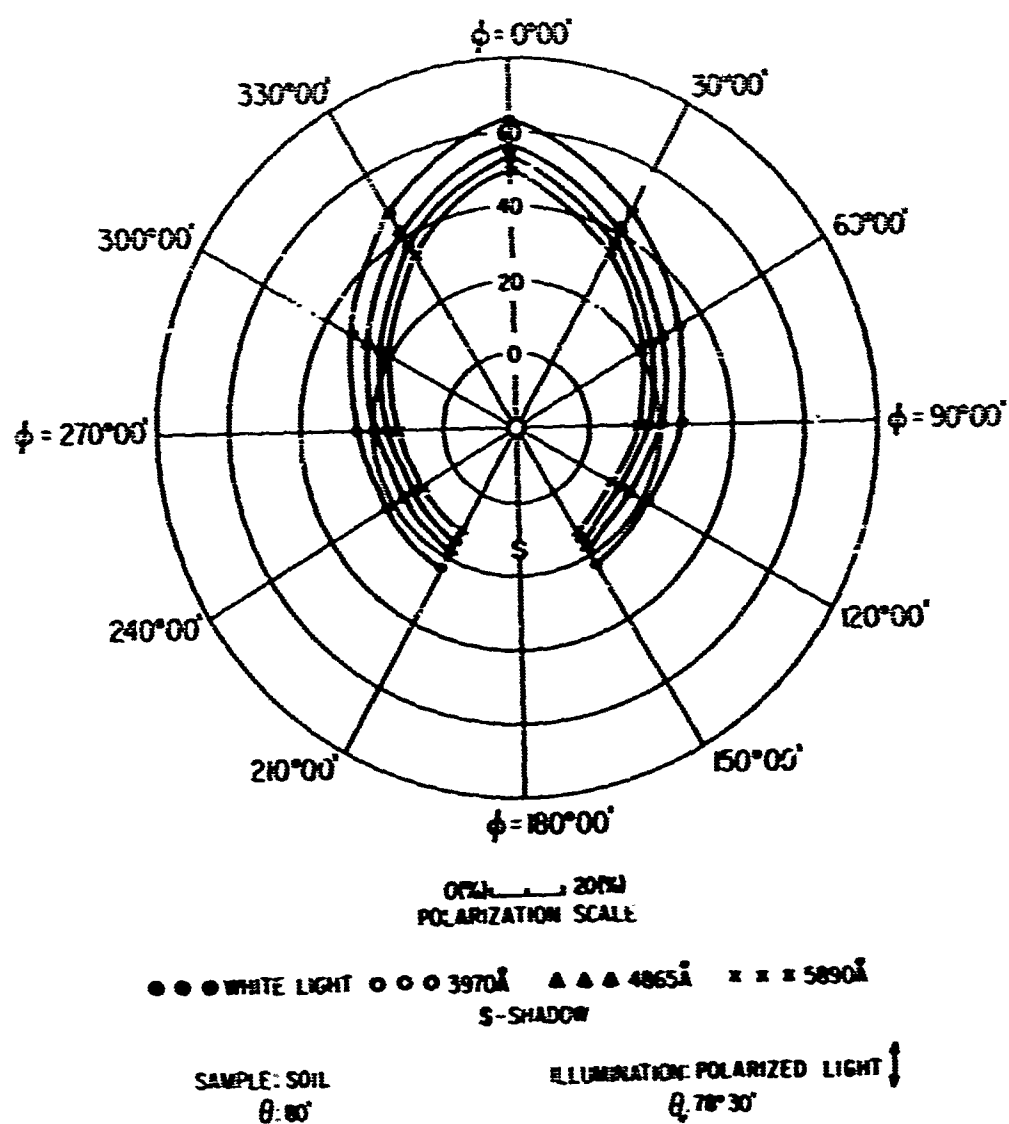


FIG 262 POLAR DIAGRAM SHOWING AZIMUTHAL VARIATION OF THE POLARIZATION OF REFLECTED LIGHT

$$\begin{aligned}
 P(\phi) = & 23.59 + 15.06 \cos \phi + 8.92 \cos 2\phi + 3.30 \cos 3\phi + 2.48 \cos 4\phi + 2.14 \cos 5\phi \\
 & + 1.02 \cos 6\phi + 0.20 \sin \phi + 0.14 \sin 2\phi + 0.08 \sin 3\phi + 0.08 \sin 4\phi + 0.03 \sin 5\phi
 \end{aligned}$$

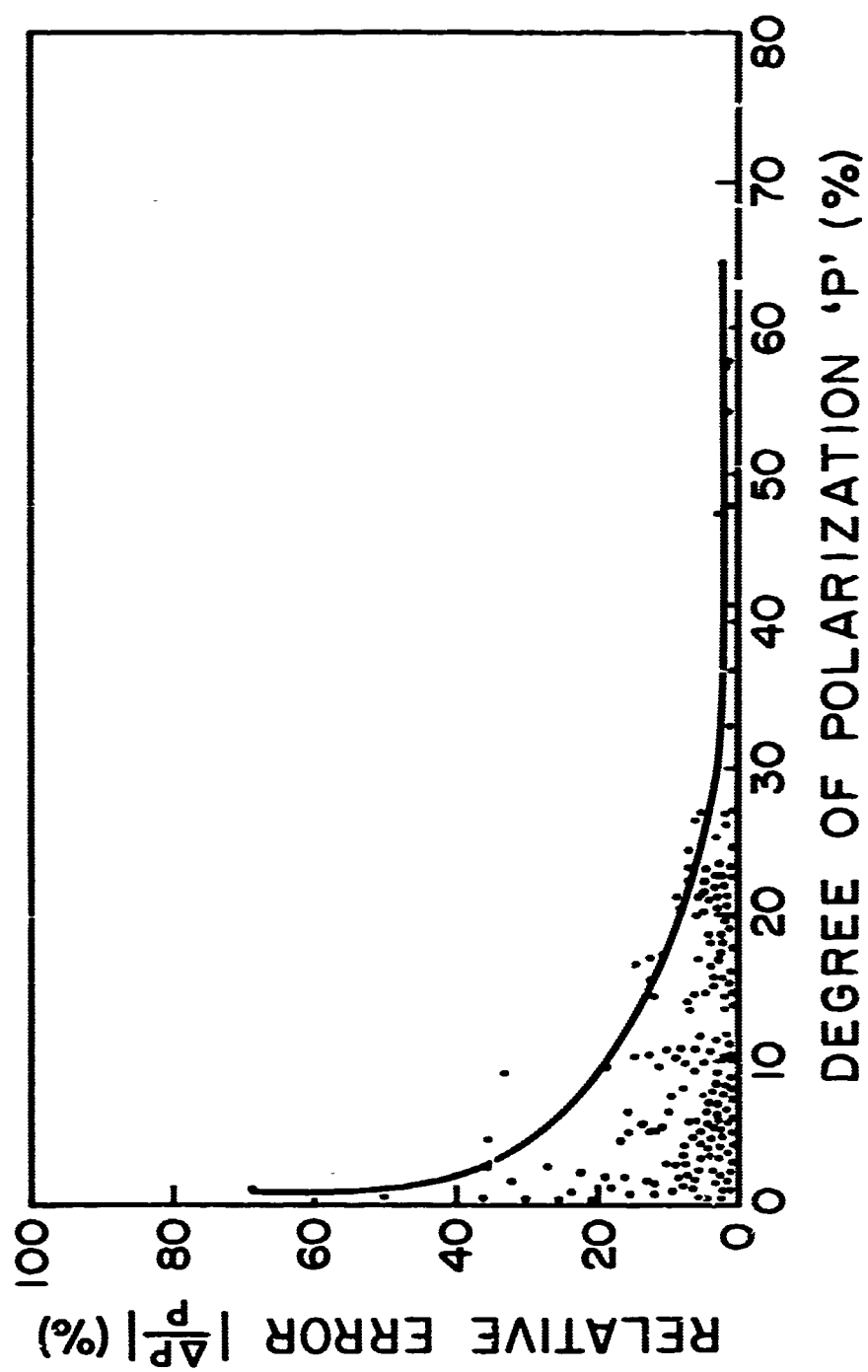


FIG. 263. THE ERROR CURVE

Unclassified

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13. ABSTRACT The results of an extensive series of measurements of the degree of linear polarization of light bidirectionally reflected by samples of desert sand, white sand and soil under various conditions of illumination are presented in graphical form. Measurements have been made in three spectral intervals (bandwidth ~ 150 Å) centered on $\lambda\lambda$ 3970, 4865 and 5890 Å and 'white light' with a simple rotating analyzer type reflectometer. Simple Fourier series representations have been established for the azimuthal dependence of the degree of linear polarization of the reflected light for 'white light' measurements. The results of the corresponding error analysis are shown in an error curve.		

DD FORM 1473

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POLARIZATION OF REFLECTED LIGHT									
1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Unclassified

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